Iron and Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

FEBRUARY, 1951

TECHNOLOGY DEPT.

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Shaping Metal for all Industry

Ohio Rolls

Select from any of these eleven types of Ohio Steel and Iron Rolls:

Carbon Steel Rolls
Ohloloy Rolls
Ohioloy "K" Rolls
Roll-O-Cast Rolls
Chilled Iron Rolls
Denso Iron Rolls
Nickel Grain Rolls
Special Iron Rolls
Nioloy Rolls
Flintuff Rolls
Alloy Chilled Iron Rolls

THE OHIO STEEL FOUNDRY COMPANY

what are the FACTS ABOUT SAFETY SWITCHES?

1 IS "INTERNAL HEATING" IN SAFETY SWITCHES IMPORTANT?

Engineering research fully authenticated by outstanding authorities shows "internal heating" in Safety Switches to be the principal cause of Safety Switch failures.

2 HOW DOES "INTERNAL HEATING" CAUSE SAFETY SWITCH FAILURES?

By literally baking the life out of Safety Switch parts. It causes insulating materials to disintegrate, metal parts to warp and corrode, so switches either become inoperative or "burn up" through inability to carry the load.

3 WHAT CAUSES "INTERNAL HEATING" IN SAFETY SWITCHES?

In properly constructed Safety Switches, fuses are responsible almost exclusively for "internal heating." This is no criticism of fuses; it is unavoidable. Any fuse carrying its rated load *must* be near its melting point if it is to perform properly when an overload occurs. Any metal operating *near* its melting point must be *hot* and fuse links *are* hot, with temperatures running as high as 700 degrees Fahrenheit.

4 HOW CAN THE TROUBLE FROM "INTERNAL HEATING" BE OVERCOME?

As the adequate enclosure so fundamental to *safety* in Safety Switches makes thorough venting of the trapped heated air impossible, the only escape from the ravages of "internal heating" can come through selecting materials for the internal structure and designing this structure to successfully withstand the unavoidable heat conditions to be met in service.

5 WHAT SAFETY SWITCHES AVOID "INTERNAL HEATING" TROUBLES?

Cutler-Hammer Safety Switches. Cutler-Hammer Safety Switches were completely redesigned *ten years* ago to beat "internal heating" when engineering research clearly indicated the need for *such* Safety Switches. Nine years of experience shows the Cutler-Hammer claim of better Safety Switch performance far more than a mere promise; it is a proven *fact*. Ask the men who use them. CUTLER-HAMMER, Inc., 1269 St. Paul Ave., Milwaukee 1, Wis.

CUTLER-HAMMER
SAFETY SWITCHES
C-H

IRON AND STEEL ENGINEER; published monthly by Association of Iron and Steel Engineers, 1010 Empire Bldg., entered as second class matter January 25, 1924 at Pittsburgh, Pennsylvania, under Act of Congress, March 3, 1879. $7.50 per year in United States and Canada, $10.00 foreign countries. Volume 28, No. 2.

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Piercing Mills
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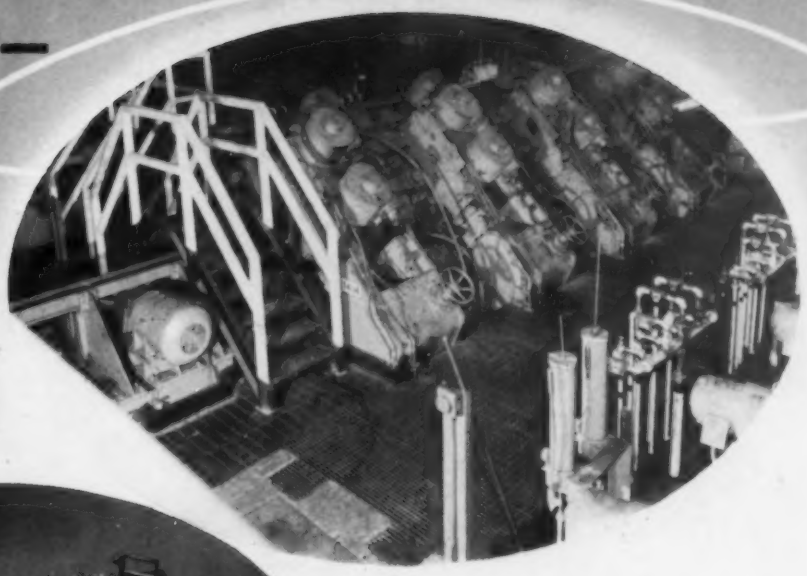
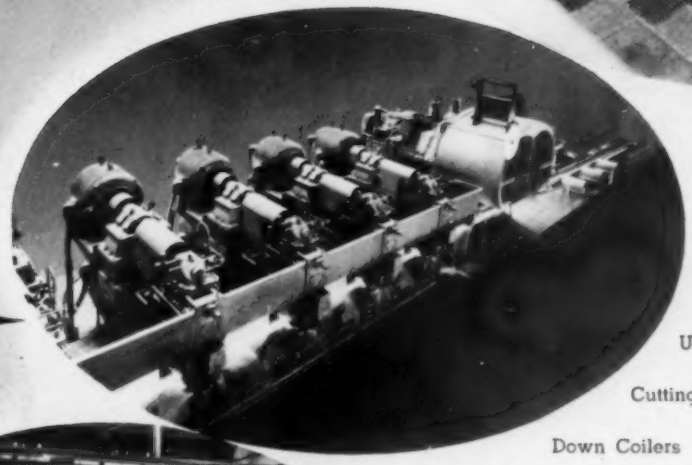


CONTINUOUS BUTT WELD PIPE MILLS



and these

Levellers • Shears • Slitters • Pilers

Side Trimming Lines • Sheet Galvanizing Lines

Upcoilers • Tension Reels • Stretcher Levellers

Cutting-off Machines • Pay-off Reels • Slitting Lines

Down Coilers • Coil Breakers • Scrubbing and Drying Lines

Bar Turning Pointer • Mill Tables • Cooling Beds • Wire Pointers

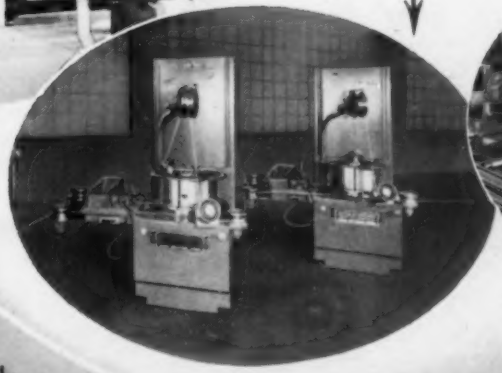
Hot Dip Tinning Equipment • Bending Machines • Rolling Mill Rolls

Side Trimmers • Continuous Pipe Galvanizing Equipment

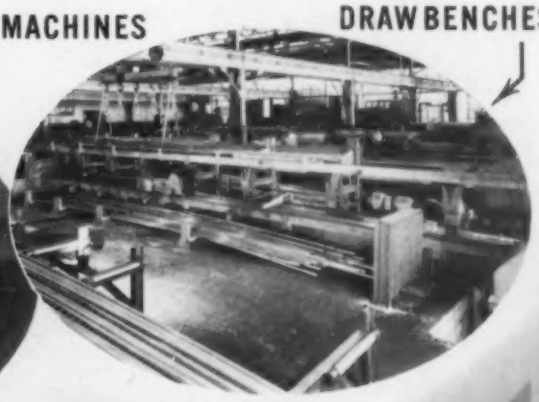
CONTINUOUS LINES

Continuous Strip Galvanizing Lines
Continuous Strip Long Terne Lines
Continuous Electrolytic Tinning Lines

WIRE DRAWING MACHINES



DRAWBENCHES



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Head Wrightson Machine Company, Ltd., Middlesbrough, England—Great Britain, Finland, Sweden, Norway, Denmark, Union of South Africa, Northern and Southern Rhodesia.

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Plants in Warren, Ohio · Ellwood City, Pennsylvania

METALLURGICAL SKILL
To meet your individual requirements for hardness, wear-resistance, composition, National's metallurgical staff is constantly alert to see that the right ingredients in the right amount are mixed to assure you high quality rolls.
NATIONAL ROLLS
EXPERIENCE
In casting rolls, many problems arise that cannot be solved by "the book"; it requires long experience in metallurgy. National has been making all types of rolls for more than forty years for metal rolling and forming.
What's behind the National Rolls you specify?
QUALITY CONTROL
Composition, heat-treatment, hardness, chill depth and other characteristics are carefully charted and indexed for each job.
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To precision-finish rolls to the closest tolerance, National uses the most modern machine tool equipment which, in the hands of National's machinists, assures you rolls finished to your specifications.
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Leading rolling mills throughout the country are listed among National roll users. They know that they can depend upon National for durable performance on the stands.
THE NATIONAL ROLL & FOUNDRY CO.
AVONMORE, PENNSYLVANIA
Specialists in Iron and Alloy Iron Rolls

REDUCE ROLL NECK MAINTENANCE COSTS

TO OBTAIN economical and trouble-free performance of oil film roll neck bearings, use *Texaco Regal Oils*. These heavy-duty turbine-quality oils keep circulating systems clean, thus assuring a constant flow of cool, clean lubricant to the bearings. Bearings last longer . . . efficiency and production go up . . . maintenance costs go down.

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For efficiency and economy in pinion stands and reduction drives, protect heavy-duty enclosed gears with *Texaco Meropa Lubricants*. Gear and bearing life is greatly prolonged with these "extreme pressure" and foam-resistant lubricants.

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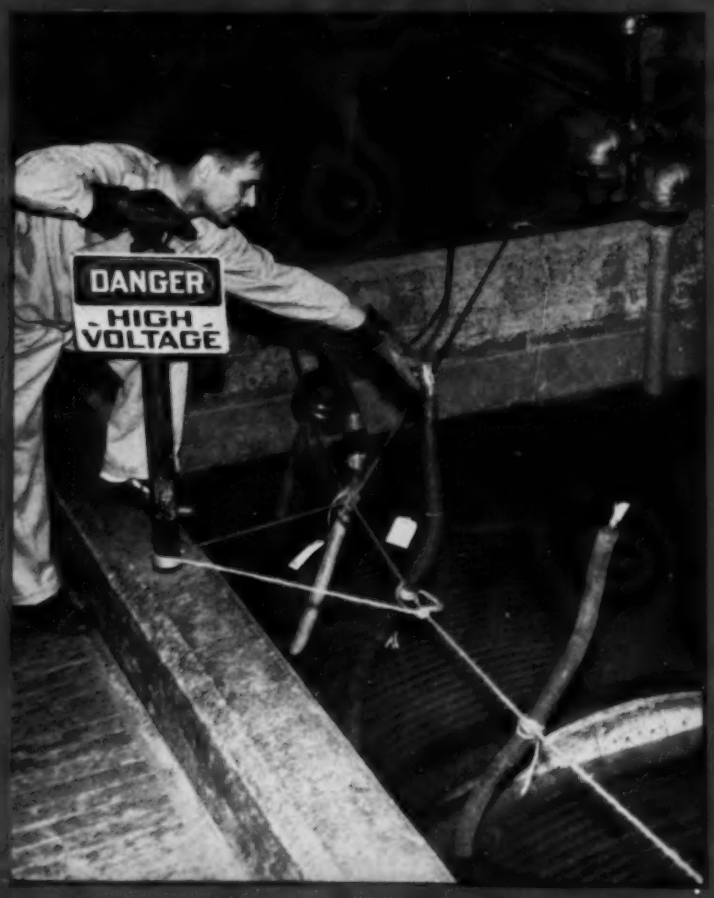
(HEAVY CIRCULATING OILS)

TUNE IN . . . TEXACO presents MILTON BERLE on television every Tuesday night. METROPOLITAN OPERA radio broadcasts every Saturday afternoon.

THIS SUPER-VOLTAGE TESTING OF OKOLITE-OKOPRENE assures lasting circuit security



There is one reason why:

In any cable, tiny and hidden imperfections may not show up at ordinarily-specified test voltages. In actual service, such imperfections can be most treacherous since at normal operating voltage they may not result in dielectric breakdown for several years. Only by the use of super-voltages, both a-c and d-c, are such concealed defects disclosed.

Okonite super-voltage testing is the severest in the industry. For example, Okolite-Okoprene non-shielded 5000-volt cables are first tested at a-c voltages approximately 25% greater than called for by standard specifications. Then, in addition, Okonite applies d-c tests at least *three times as high* and for periods *three times as long* as these super-voltage a-c tests. Ordinary cables are not subjected to such tests because they do not possess that extra margin of dielectric strength that Okolite-Okoprene provides. Only a cable made with premium materials and the exclusive Okonite strip process can reliably pass such tests.

Without exception, Okonite applies these self-imposed super-voltage tests to *every foot* of *all* Okolite-Okoprene cables for *all* voltage ranges—and after 12 hours immersion in water. That's why, when you specify Okolite-Okoprene cables, you can be sure of uninterrupted, trouble-free service—lasting circuit security—year after year after year. The Okonite Company, Passaic, N. J.

THE BEST CABLE IS YOUR BEST POLICY

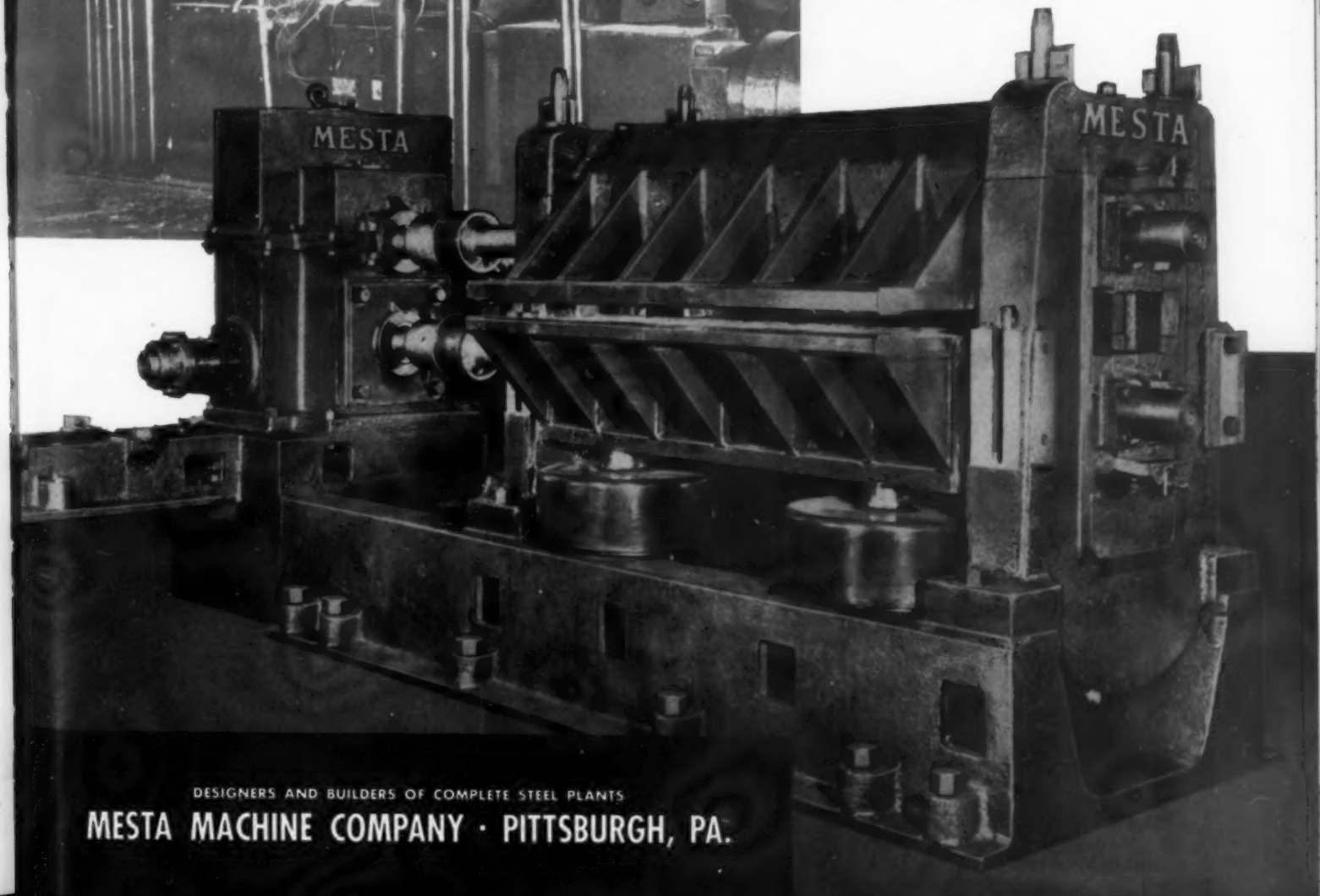
OKONITE SINCE 1878 *insulated wires and cables*

8554

MESTA
Rotary Flash Trimmer

The Mesta Rotary Flash Trimmer* together with the Mesta-Thomson Flash Welder forms a combination for increasing the speed of continuous pickling lines. After welding, strip is clamped in position in the Trimmer and excess flash from the weld is trimmed to normal thickness. The Trimmer also shaves the strip adjacent to both sides of the weld to eliminate any variation in the thickness between trailing end and leading end of coils.

*Patent Pending



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MESTA MACHINE COMPANY · PITTSBURGH, PA.

Modernization is a *Must!*

USE BILLETEERS!

Resounding hammer of the village blacksmith rings through early American industrial history. But would you trade your modern forging equipment for a brawny arm and a heavy sledge? *No! —Not for a whole battery of them!* In billet-cleaning, like forging, new methods pay handsomely. Here's how today's proven production of the Bonnot Billeteer stacks up against out-moded hand methods of billet-conditioning.

MANUAL CHIPPING	BILLETEER CONDITIONING
Labor costs high.	Labor costs reduced as much as 56%.
Slow, grueling operation.	Easy machine operation; does better work ten times faster.
Partial chip salvage.	Chips 100% recoverable.
Extremely hazardous.	Outstanding safety records such as 490,000 manhours with only one disabling accident.
Large inventory needed.	Minimum inventory and dependable, scheduled production.
Employee turnover high.	Fewer personal problems because men like to operate Billeteers.
Jitters and fatigue drastically limit span of worker's usefulness.	By contrast, rugged Billeteer stands the punishment—in many cases exceeding 100,000 hours of efficient performance, and with no absenteeism.

Engineered for Improved Production . . .

The Bonnot Co.
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Let us show you how much the Bonnot Billeteer can save you in billet-conditioning and manpower costs — Write today!

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SQUARE D's *New*

SAFETY SWITCHES

***Types A, C and D**

Backed by 40 years' DESIGN LEADERSHIP

The remarkable superiority of this new switch line is reflected in these TYPE A design and operating features:

MODERN STYLING is both functional and attractive.

COMPACTNESS obtained without sacrifice of wiring convenience.

FULL COVER INTERLOCK has attachment that locks switch "ON" or "OFF" with 1, 2, 3 or 4 padlocks of nearly any size or shape.

SIMPLE MECHANISM—quick make-and-break action—no dead center.

SILVER-PLATED current-carrying parts.

EXPOSED BLADES permit visual checks of switch operation.

DEAD-FRONT line terminals are protected by hinged arc chamber cover.

MAGNETIC ARC PLATE adds to unusually high rupturing capacity.

POSITIVE PRESSURE jaws and fuse clips, steel reinforced, silver-plated.

NON-TRACKING insulation used in base. Melamine insulating cross-bar.

REMOVABLE PRESSURE CONNECTORS permit substitution of solder lugs, where preferred.

Types* **C *and* **D** *similar to Type* **A** *in appearance—differ in construction details*

NOW in production: 30, 60, 100 and 200 ampere sizes

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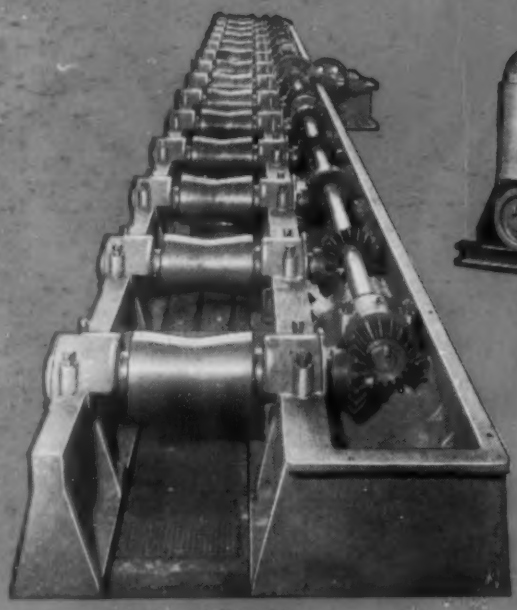
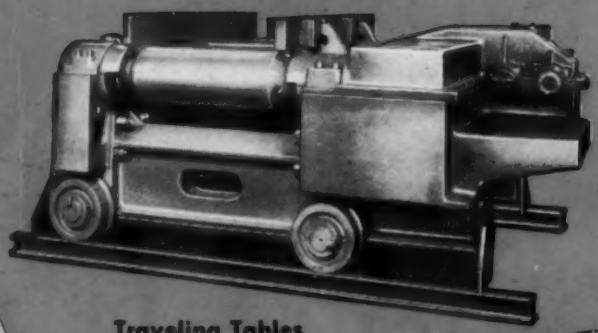
Continental

MILL TABLES

for every purpose, for all mills



Tube Mill Tables



Traveling Tables

Merchant Mill Tables

PRODUCERS OF: Complete Rolling Mill Installations including:

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Structural Mills
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Plate Mills
Slabbing Mills
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Non-Ferrous Mills
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Transfers
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IRON, ALLOY IRON and STEEL ROLLS for ferrous and non-ferrous rolling mills; pulp and paper industry; textile industry; and milling, cereal and vegetable oil industries.

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PLANTS AT: EAST CHICAGO, IND., WHEELING, W. VA., PITTSBURGH, PA.

For a full 3000F
JM-3000
For use to 2800F
JM-28
For use to 2600F
JM-26
these 6 types of Johns-Manville Insulating Fire Brick are designed to bring you important fuel savings
For use to 2300F
JM-23
For use to 2000F
JM-20
For use to 1600F exposed
For use to 2000F as backup

You can make important savings in fuel by taking advantage of the quick heating characteristics of J-M Insulating Fire Brick. These light-weight brick permit a quicker rise to proper operating temperature in the furnace because of their low heat storage capacity, and low thermal conductivity. Where furnaces are being intermittently operated these are two especially important characteristics.

These same insulating materials can also be obtained in large size units called Johns-Manville Insulating *Fireblok*. This product has many advantages over the smaller size fire brick for certain types of jobs . . . from both a construction and stability standpoint. The Fireblok units can be quickly applied because they are easy to cut and fit. Fireblok insulations provide additional heat savings because they reduce the number of joints, and require less mortar for bonding.

It will pay you to let a Johns-Manville insulation engineer explain the many ways in which you can save by using these insulations in your furnaces. Just write for further information to Johns-Manville, Box 290, New York 16, N. Y.

JM PRODUCTS

	JM-1620	JM-20	JM-23	JM-26	JM-28	JM-3000
Densities, lb per cu ft.	29	35	42	48	58	63-67
Transverse Strengths, psi	60	80	120	125	120	200
Cold Crushing Strengths, psi	70	115	170	190	150	400
Linear Shrinkage†, percent	0.0 at 2000 F	0.0 at 2000 F	0.3 at 2300 F	1.0 at 2600 F	4.0 at 2800 F	0.8 at 3000 F
Reversible Thermal Expansion, percent.	0.5—0.6 at 2000 F	0.5—0.6 at 2000 F	0.5—0.6 at 2,000 F	0.5—0.6 at 2000 F	0.5—0.6 at 2000 F	0.5—0.6 at 2000 F
Conductivity* at Mean Temperatures						
500 F	0.77	0.97	1.51	1.92	2.00	3.10
1000 F	1.02	1.22	1.91	2.22	2.50	3.20
1500 F	1.27	1.47	2.31	2.52	3.00	3.35
2000 F	—	1.72	2.70	2.82	3.50	3.60
Recommended Service						
Back up	2000 F	2000 F	2300 F	2600 F	2800 F	3000 F
Exposed	1600 F	2000 F	2300 F	2600 F	2800 F	3000 F

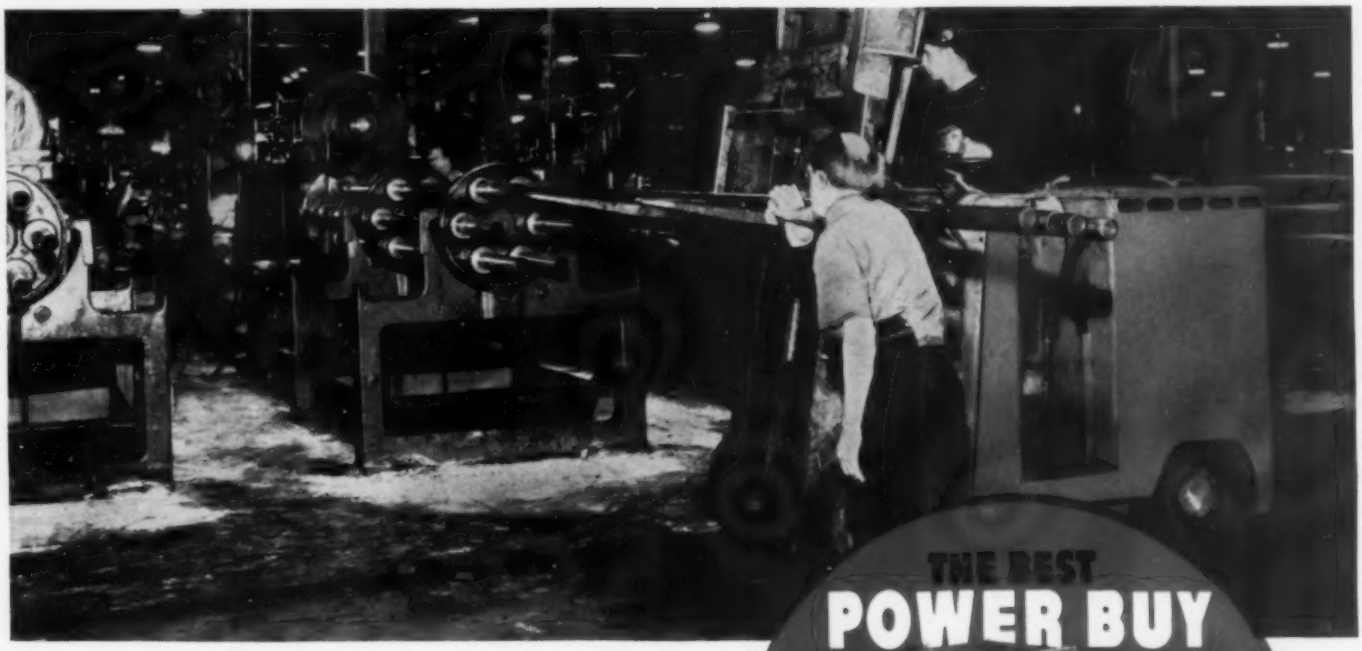
†24-hr. simulative service panel test for JM-3000; 24-hr. soaking period for other brick.

*Conductivity is expressed in Btu in. per sq ft per F per hour of the designated mean temperatures.

Note: Above tests are in accordance with A.S.T.M. tentative standards.

Johns-Manville *first in* **INSULATIONS**

IT COSTS $5.50 A DAY TO FEED AN ELEPHANT... ONLY 34 CENTS TO "FEED" AN Exide-Ironclad BATTERY



Thirty-four cents a day pays the full power cost of an Exide-Ironclad battery-powered industrial truck. Lifting, hauling and tiering all day long, it handles more tonnage than a herd of husky tuskers could move in equal time.

But low power cost is only part of the Exide story. In addition, Exide-Ironclad Batteries bring you these important benefits.

INSTANT SURGE OF POWER, plus finger-tip control, split-second handling, easy maneuvering, accurate spotting.
ROUND-THE-CLOCK PERFORMANCE—no mechanical troubles, no unscheduled down time.
UNIFORM SPEED straight through to end of shift.
LOW MAINTENANCE COSTS—seldom more than 15 cents per shift.
EXCEPTIONALLY LONG LIFE—proved on more than 100,000 heavy-duty jobs.
INHERENT SAFETY—no vibration to jar goods in transit, less worker fatigue and accident hazards.

There are Exide-Ironclad Batteries for every size and make of battery electric truck.

Write for more facts and FREE copy of Exide-Ironclad Topics. It contains latest developments in materials handling . . . shows actual case histories.

THE ELECTRIC STORAGE BATTERY COMPANY
Philadelphia 32
Exide Batteries of Canada, Limited, Toronto
"Exide-Ironclad" *Reg. Trade-mark U.S. Pat. Off*

1888 . . . DEPENDABLE BATTERIES FOR 63 YEARS . . . 1951

ALLIS-CHALMERS AIDS CONVERSION PROGRAM AT AMERICAN BRASS COMPANY

WHETHER FERROUS OR NON-FERROUS, the metal producer will get *skilled* attention from Allis-Chalmers on electrical needs. The Kenosha, Wis. copper tube mill of The American Brass Co. shows how Allis-Chalmers equipment assists the non-ferrous metal producer.

This mill was built during the last war to roll brass for small arms ammunition. Allis-Chalmers equipment driving and controlling the hot rolling mills proved so satisfactory that more Allis-Chalmers equipment was specified in the post-war conversion to non-ferrous tube manufacture.

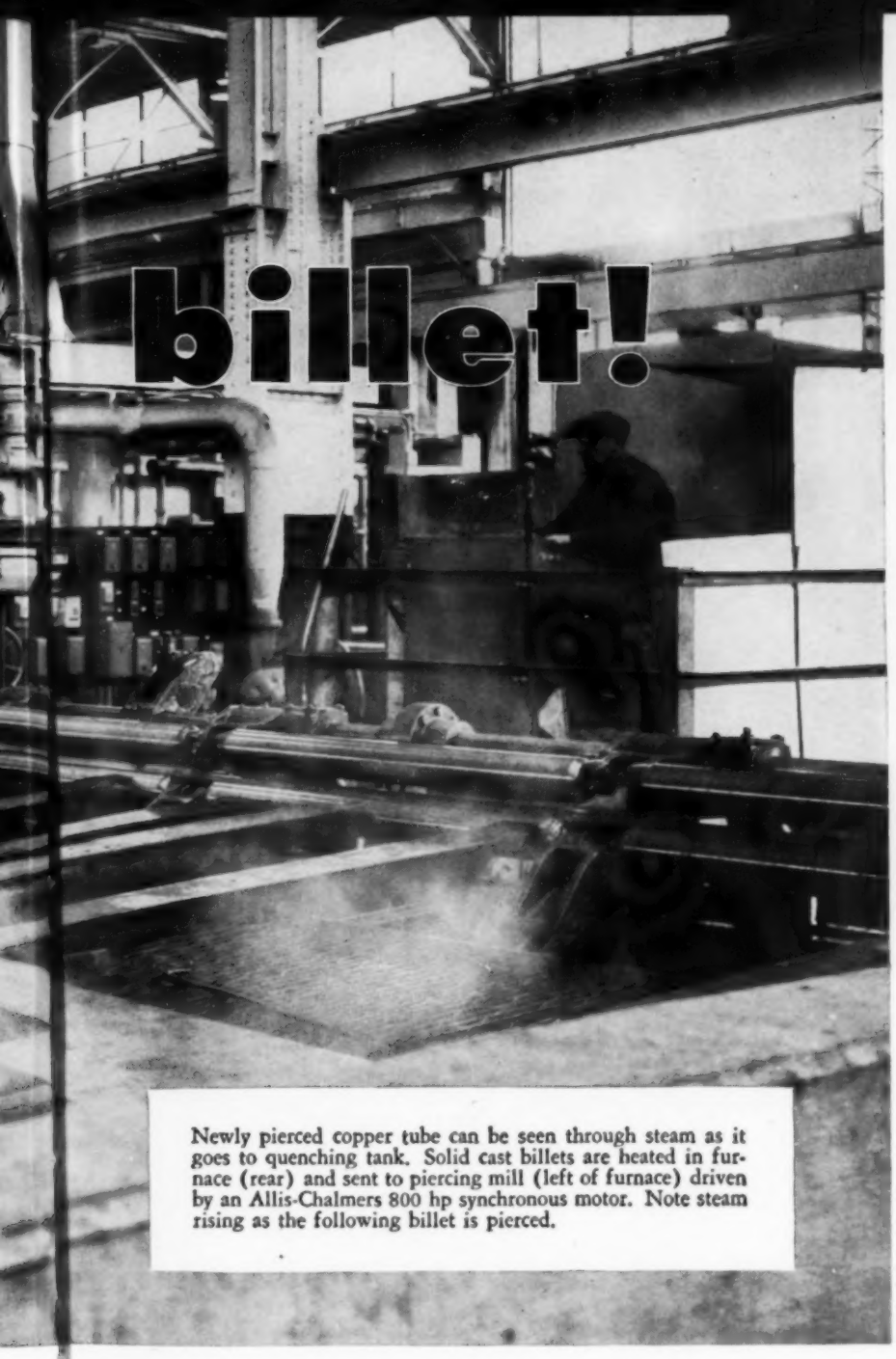
ALLIS-CHALMERS EQUIPMENT INSTALLED

In this conversion, Allis-Chalmers supplied the rotating equipment, switchgear and control for the piercing mill, hydraulic squeeze pointer, and three 100,000 lb triple draw-benches. The supporting Allis-Chalmers motor-generator sets and switchgear are in an enclosed Motor room (lower right), for which Allis-Chalmers supplied the ventilating equipment.

Power, Electrical, Processing Equipment for Metal Industry

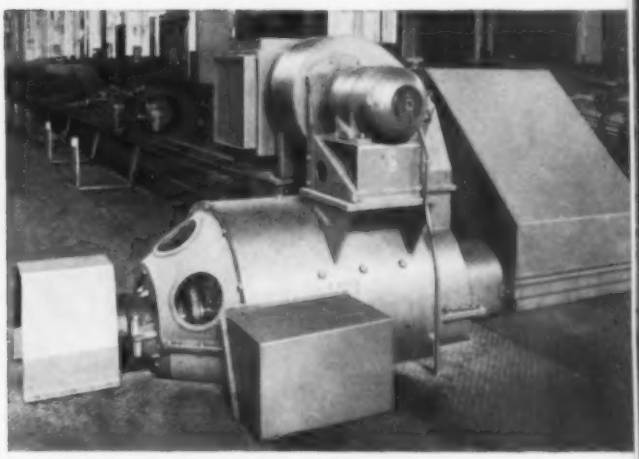
ALLIS-

billet!

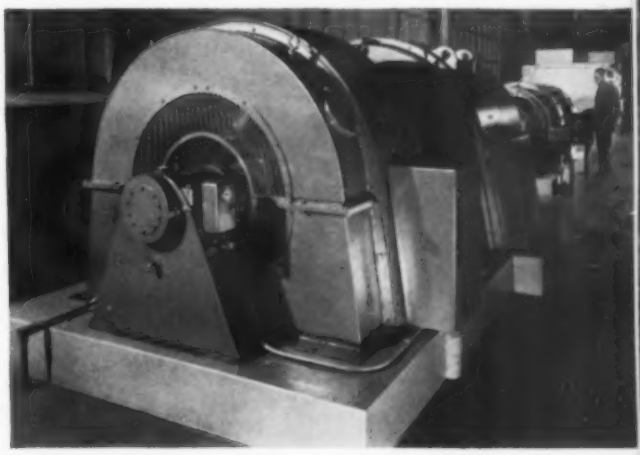


Newly pierced copper tube can be seen through steam as it goes to quenching tank. Solid cast billets are heated in furnace (rear) and sent to piercing mill (left of furnace) driven by an Allis-Chalmers 800 hp synchronous motor. Note steam rising as the following billet is pierced.

Closeup of drive side of piercing mill. Allis-Chalmers synchronous motor driving piercing mill is rated 800 hp, 2300 volts, 720 rpm. After quenching, tube goes to hydraulic squeeze pointer (not shown). Squeeze pointer pump is driven by an Allis-Chalmers 60 hp totally enclosed squirrel cage induction motor.



After squeeze pointing, one of three 100,000 lb triple drawbenches reduces the tube to desired size. The Allis-Chalmers 300 hp dc motors are equipped with *Frog-Leg* armature windings for improved commutation. All auxiliary motors, including 5 hp blower motors and 5 hp dc carriage return motors, are also Allis-Chalmers.



Motor room. Synchronous M-G set in foreground, rated 750 kw at 250 volts dc, supports three 100,000 lb drawbenches. Mill supply dc provided by the 300 kw, 1200 rpm M-G set (center). Complete switchgear, dc (right) and ac (rear), also supplied by Allis-Chalmers. *Ruptair* magnetic air breakers of 100,000 kva i.c. are used.

The three 100,000 lb triple drawbenches (one seen at center right) are among the largest ever made. Built by Aetna-Standard Engineering Co. and powered by Allis-Chalmers drives, they can draw copper, brass and alloy tubes up to three in. diameter and 125 ft long.

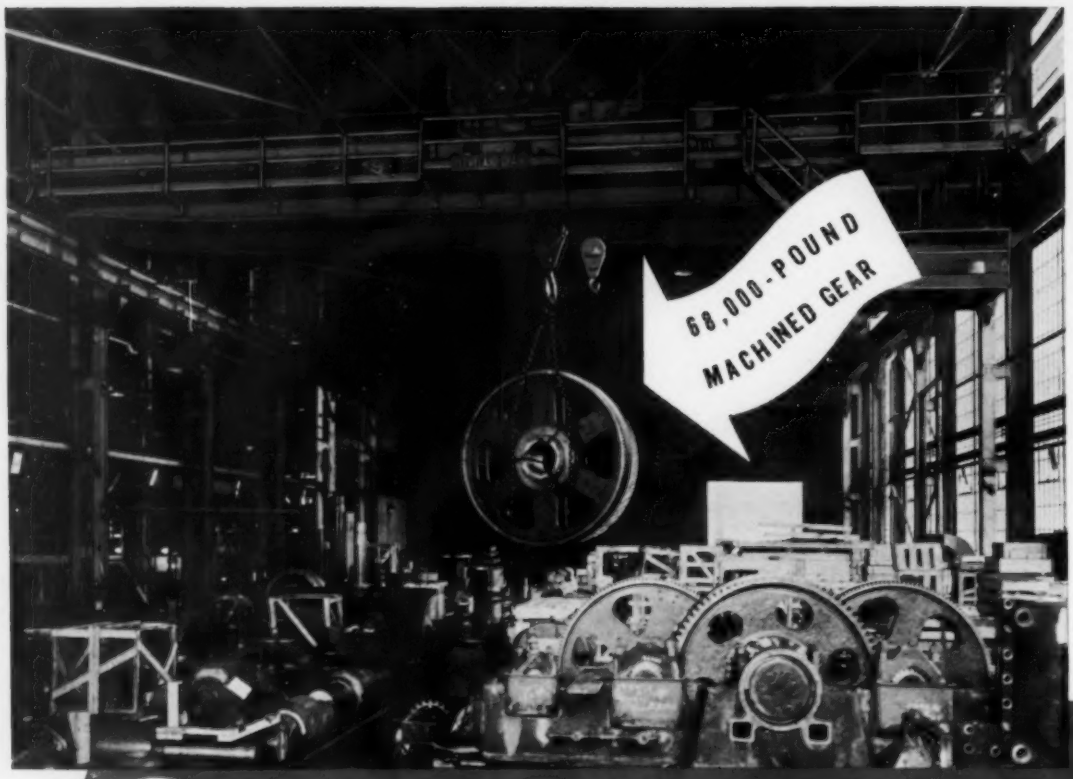
MEET YOUR ELECTRICAL NEEDS

Your conversion or expansion program can also take advantage of Allis-Chalmers wide experience in building and applying electrical equipment in the metal industry. A-C builds a complete range of generation, switching, conversion, rectification, drive, and control equipment. For specific information, call your nearest A-C office or write to Allis-Chalmers, Milwaukee 1, Wisconsin. A-3307

Frog-Leg and *Ruptair* are Allis-Chalmers trademarks.

S- CHALMERS

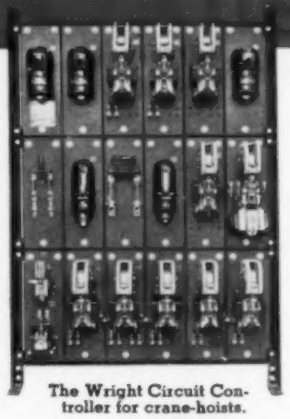
A-C ALLIS-CHALMERS



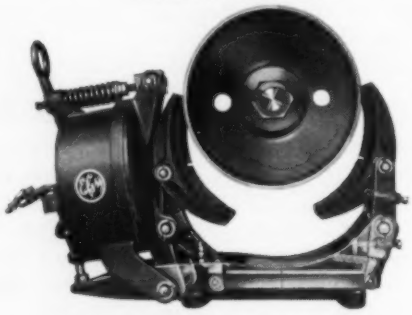
Pin-Point Accuracy IN SPOTTING —AN EC&M HOIST CONTROL FEATURE

The EC&M Wright Circuit Controller and the EC&M Type WB Brake are an unequalled combination for D.C. crane-hoists. The Wright Circuit puts all the current from the line on the first point lowering through the coil of the quick responding WB Brake. The result is *fast brake release*—accurate spotting of loads with a minimum number of movements of motor, contactors and brake. Maintenance men recognize this as a contributing factor to reduced up-keep.

The operator has complete control of the load at all times in lowering. The Wright Circuit is SAFE! Specify EC&M Control when buying new cranes or revamping existing ones.



The Wright Circuit Controller for crane-hoists.

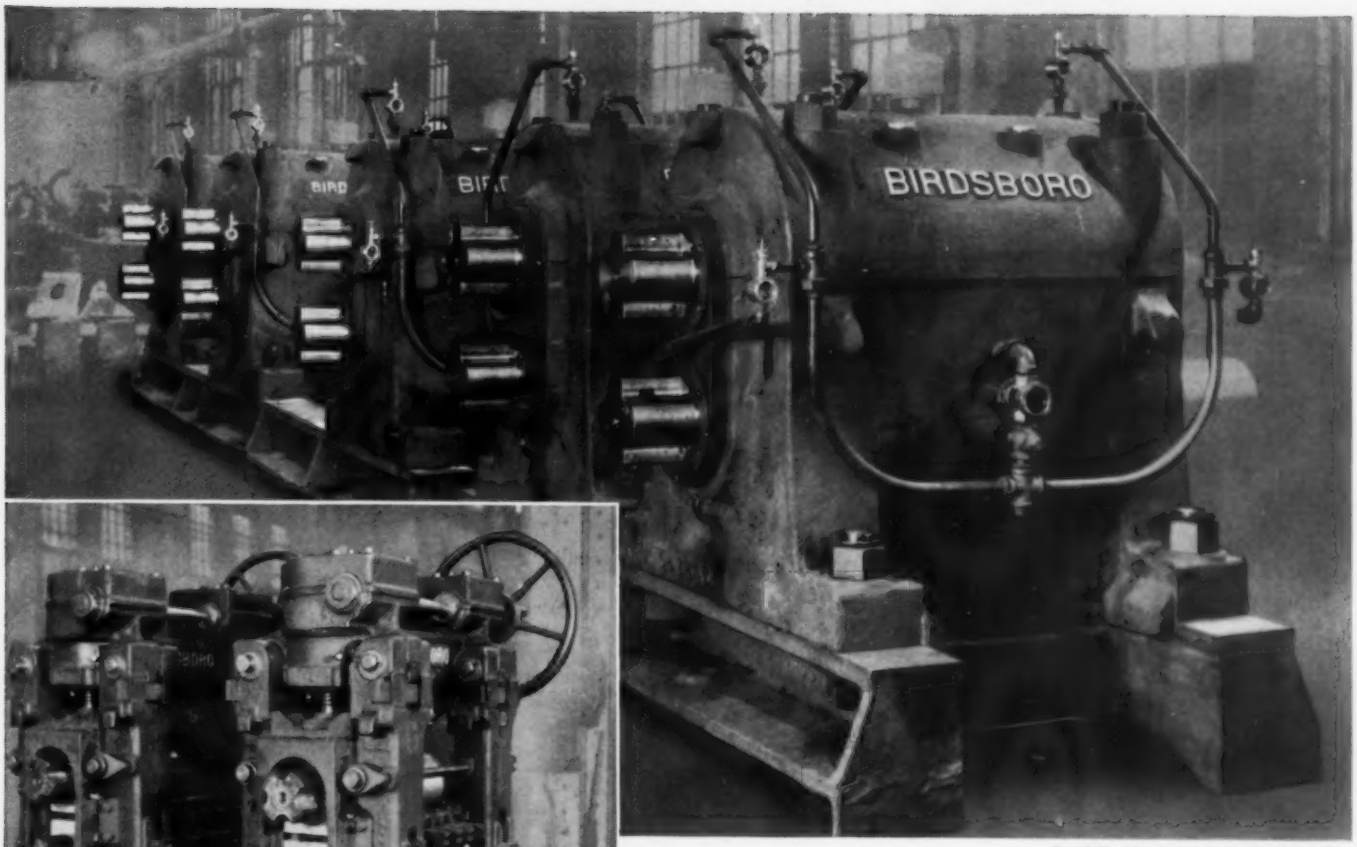


Type WB Brake for hoist motors.

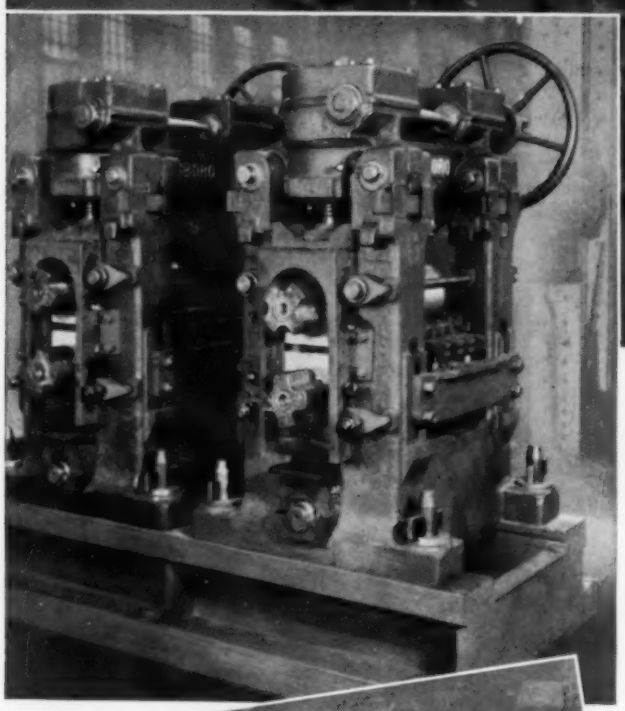
Photograph—Courtesy, Cleveland Crane and Engineering Co.

E&M

THE ELECTRIC CONTROLLER & MFG. CO.
2698 EAST 79TH STREET • CLEVELAND 4, OHIO



Semi-Continuous Rod Mill—14" Roughing Mill Pinion Stands.



10" Semi-Continuous Rod Mill Intermediate Stands.

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Birdsboro's experience, advanced engineering, complete production facilities and highly skilled craftsmen—all contribute to the design and construction of all types of steel mill machinery that is helping to step up output and reduce operating costs of leading plants here and abroad.

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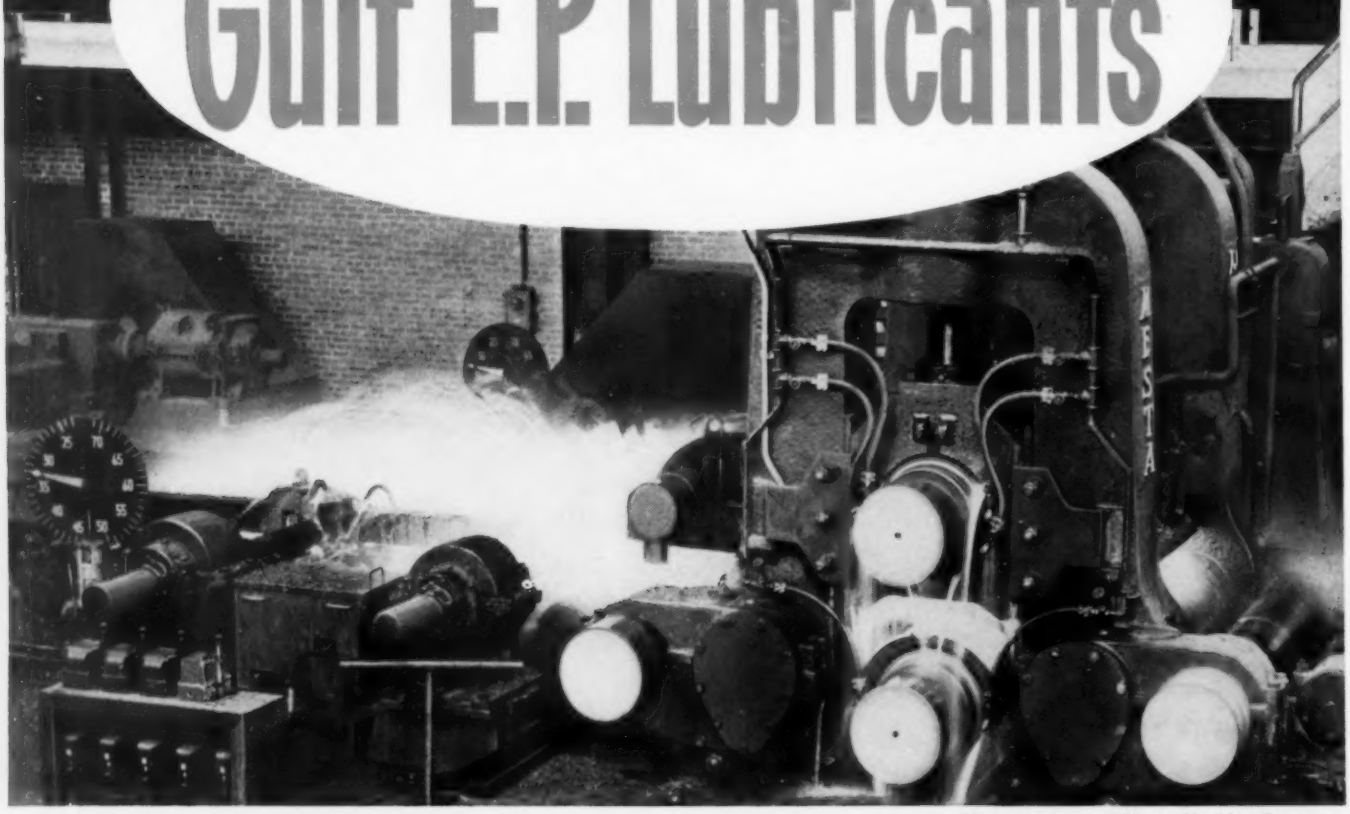

Photo courtesy of Mesta Machine Company

Gulf E.P. Lubricants have proved their outstanding ability to protect gear teeth against overloads and shock loads in steel mill pinion and gear drives.

Now a recent laboratory investigation of seven different brands of extreme pressure lubricants demonstrates the superiority of Gulf E.P. Lubricants in regard to water separating characteristics. All grades of Gulf E.P. Lubricants, after being agitated with an equal quantity of water for five minutes, showed more than 90% separation after only one minute's rest. None of the other lubricants tested approached this degree of separation under the test conditions.

Here's what this means to steel mill users! With the most suitable Gulf E.P. Lubricant for each application and good maintenance practice, you can avoid deterioration of the lubricant in the presence of water and the formation of harmful emulsions. Gulf E.P. Lubricants are the answers for table drives, pinion stands, reduction gears, and screw downs.

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For complete details on Gulf E.P. Lubricants and for expert help on any problem that involves lubricants or lubrication, call in a Gulf Lubrication Engineer today. Write, wire, or phone your nearest Gulf office. Gulf Oil Corporation · Gulf Refining Company, Gulf Building, Pittsburgh 30, Pennsylvania.

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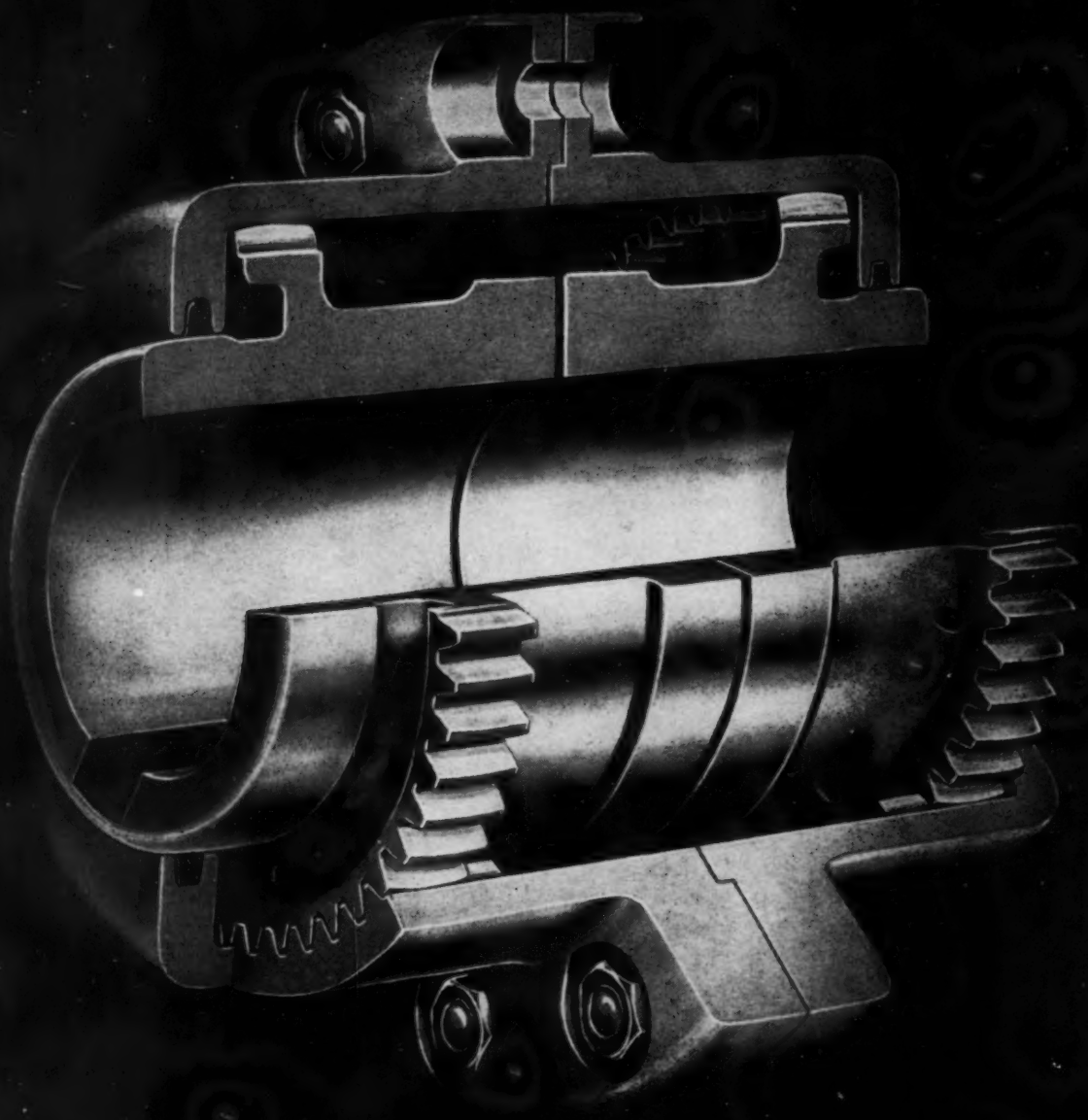

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(1) Materials Handling Handbook

A new, 72-page book is a practical guide for the analysis of material handling operations and the application of the unit-load method with battery powered industrial trucks and accessories. It is well illustrated and contains many useful charts and diagrams, together with engineering data.

This new Handbook of Material Handling is divided into four sections: The Evaluation of Industrial Truck Handling; (2) Material Handling Management, with subsections devoted to the preparation and use of flow process charts, handling operations in production, handling in storage, the use of unit loads in storage, with layouts, commodity and capacity factors, etc.; (3) The Organization of an Industrial Truck System and, (4) Practical Truck Engineering. Electric Industrial Truck Association.

(2) Dust Control Technology

Detailed selection, operation, and maintenance data for the plant engineer responsible for dust control is contained in a 50-page book —"Industrial Dust Control Through Exhaust Systems." The book treats, in three major sections, (1) Exhaust Hoods and Piping Systems, (2) Dust Collecting Equipment, and (3) Exhausters and Drives. To make the book specifically helpful to the individual reader, a detached problem sheet is included on which the reader can enter data particular to his case. Compilation of this data expedites the work of the dust control engineer when working out system details. Pangborn Corp.

(3) Liquid Level Gages

A new 24-page bulletin on water level gages has just been published. The bulletin describes instruments for measuring and recording water depth. Float, pressure bulb, pressure, counterpoise, differential pressure, and air-bubbler types of liquid level gages for a variety of uses are described, including the measurement and automatic control of water and other liquids and solutions, whether flowing, turbulent, corrosive, under static pressure, covered with ice, or carrying solid matter. The bulletin also contains information on remote recording and remote automatic pump control of water level with Metameter telemetering instruments. (L700) Bristol Co.

(4) Steel Mill Straddle Trucks

Featured in a new straddle truck catalog just issued is the Model "MHS," especially designed for handling steel. A variation of the standard 30,000-lb capacity Model "MH" straddle truck, the new model, according to the catalog, is intended for extreme service encountered in materials handling in the metal industry. Principal among a number of improvements and optional advances for extended utility are double-row roller chains in the hoist mechanism instead of single-row chain as in conventional trucks; solid bar rather than channel sections in the lifting links; additional carrying capacity of the suspension springs, and heavier frame in the cross members and corner sections. (1375) Hyster Co.

(5) Five Combustion Booklets

The availability of five case histories on combustion control has been announced. Each report is devoted to a complete discussion of the experience of one company with combustion control. Each includes a description of: (a) The problems facing boiler plant personnel before installing control. (b) The specific conditions (load swings, steam demand, boiler rating, products produced, etc.) existing at the plant. (c) How the control system operates together with a discussion of related boiler plant equipment. (d) The results obtained with automatically controlled combustion. A schematic drawing and a number of photographs are included in each report to facilitate understanding of the installation. Hays Corp.

(6) Megger Ground Testers

Just published is a comprehensive bulletin on "Megger" ground testing instruments for measuring resistance of earth to ground connections and for measuring earth resistivity. Aids to proper selection, application, typical tests, drawings and illustrations all help to make this a valuable publication for those engaged in these important problems of grounding surveys, geophysical prospecting, electrical power and communication grounding problems, soil corrosion, electrolysis and cathodic protection. (25-27) James G. Biddle Co.

(7) Sinterforge Carbides

A new engineering bulletin is available containing timely information and engineering data on "Sinterforge Carbides" (hot pressed tungsten carbide). Sintercast Corp. of America.

(8) Open Steel Flooring

A new catalog describing various types of open steel flooring and armoring is available. The catalog discusses the different types of "Tri-Lok" open steel flooring and safety treads. It contains specification data, safe load tables, installation methods and other pertinent information. Also included is descriptive information on floor armoring and flooring. The flooring, an assembly of tee bars, when filled with concrete, is used instead of heavy concrete flooring reducing the dead load and thus permitting a lighter weight superstructure. (1103) Dravo Corp., Machinery division.

(9) Speed Control

An attractive new 12 page bulletin which describes the basic operating principle of the "Reeves" variable speed drives and contains representative rating tables and dimension drawings, is being offered. Capacities range from 1/4 to 87 hp with stepless speed changes within ratios from 2:1 to 16:1. The new bulletin covers, in condensed form, three basic units — variable speed transmission, "Vari-speed Motodrive," "Vari-speed" motor pulley — and a wide

variety of manual and automatic controls for use with them. (G-509) Reeves Pulley Co.

(10) Mill Motors and Controls

A new 20-page booklet describing 600-Series mill motors and Class 9500 d-c magnetic mill auxiliary controllers is available. The design features and construction details of the mill motors are discussed, with sections devoted to armatures, bearings, field coils, brushholders, and ventilation. The booklet points out the high starting torque of these motors, simplified construction—meeting AISE specifications—for ease of servicing and maintenance, and complete utilization of space within the frame. New Class 9500 d-c magnetic controllers for mill auxiliaries are discussed in the second section of this booklet. These controllers use the newly-developed type M contactor, which is available in NEMA ratings from 25 to 2500 amperes. The different controllers in the line are listed, with a typical circuit diagram presented and explained. Operation of the type AP plugging relays is explained. These voltage-sensitive relays are connected so that they can be adjusted accurately over a wide range to control the plugging operation. (B-4730) Westinghouse Electric Corp.

(11) Production Tools

Standard production tools are described and illustrated in 11 new catalog bulletins just published. These new bulletins replace Scully-Jones "Tool Engineering Manual 500" and any other literature previously published. The bulletins are: 1-50 Drill and tap chucks; 2-50 Arbors and adapters; 3-50 Quick change chucks; 4-50 Tap holders and drivers; 5-50 Counterbores, countersinks, and core drills; 6-50 Adjustable adapters; 7-50 Sleeves and sockets; 8-50 Floating holders; 9-50 Centers; 10-50 Recessing tools; and, 11-50 Work rest blades. Scully-Jones and Co.

(12) Feed Water Control

The latest developments in three-element feed water control are described in a new 16-page bulletin just published. The bulletin contains a straightforward, concise discussion of problems encountered in feed water control and explains how the Bailey air-operated three-element system helps solve them. Diagrams, cutaway views, typical chart records and photographs of modern installations are used in describing the control system. (105-C) Bailey Meter Co.

(13) Turbine Generators

A 40-page bulletin covering Elliott turbine-generators (500 kw and above) has just been released. Nearly 50 turbine-generator installations, both utility and industrial, are pictured and described. Brief discussions of generator and exciter cooling methods are included. A reference section offers an interesting detailed drawing showing a typical turbine-condenser installation arrangement. Dimensions and weights of standard units are tabulated for easy reference. (H-18) Elliott Co.

(14) Lubricating Equipment

Universal hydraulic grease fittings, couplers, swivel couplers, control handle for boosting grease pressures to 12,000 lb, and top oiler for upper cylinder lubrication are illustrated and described in a 14-page industrial catalog just published. Universal Lubricating Systems, Inc.

(15) Corrosion Proof Linings

Publication is announced of a new corrosion proof linings bulletin. This bulletin describes Atlas' complete line of corrosion proof linings, including: sheet linings, solution or dispersion linings, brick sheathings and miscellaneous linings. (4-1) Atlas Mineral Products Co.

(16) Electrolytic Cleaning

Just published is a revised and enlarged edition of a popular electrolytic cleaning booklet entitled, "An Introduction to Electrolytic Cleaning." The revised edition contains information on the fundamentals of electrolytic cleaning, the phenomena that takes place during electrolytic cleaning, the differences between the various electrolytic cleaning processes, the attributes of a good electrocleaner, considerations in the choice of an electrocleaner for any particular process, etc. New in this enlarged edition are the cleaning of die-cast metals, the cleaning of cuprous metals including reverse current cleaning, without discoloration, soaker tank cleaning and paint stripping. Du Bois Co.

(17) Strip Chart Recorders

A bulletin is available describing the "Capacilog" line of electronically operated strip chart recorders. In addition to explaining how direct deflection, Wheatstone bridge circuit and pneumatic control types of operating systems are applied to "Capacilogs," the bulletin also lists model numbers and specifications of the various recorders and recorder-controllers. A separate price list supplements the bulletin. (C2-2) Wheelco Instruments Co.

(18) Rotary Straighteners

Eleven models of rotary straighteners which remove the bends, bows, waves and kinks from tubing or pipe of any metal are illustrated and described in a new catalog just issued. According to this new literature, these straightening machines handle tubing in all sizes down to $\frac{1}{8}$ in. outside diameter, and pipe up to 15 in. in diameter. Production speeds range from 120 ft to 600 fpm and up. The catalog reviews the design and construction of these rotary straighteners. It comments that only one set of rolls is needed to handle the entire size range of each model. Illustrations include pictures of various models at work in pipe and tube shops. A model specification and dimension table is presented. It lists tube and pipe sizes handled by each of the eleven rotary straighteners; production speeds, horsepower of motors, number of driven rolls and their size; plus indicating the floor space and weight for each model. (7265) Mackintosh-Hemphill Co.

(19) Research Instrument Review

The acceleration of research through the use of industrial and related instruments and apparatus is the subject of an 84-page book just published. The book describes many types of equipment which, alone or in combination with other apparatus, are being used in research and analytical studies. In addition to the importance of the publication as a reference and application guide for researchers and analysts, the book reflects the great strides made in the instruments field since World War II. It also emphasizes how extensively industrial instruments are being used alone or in combination with others for technical, engineering and laboratory work. The company has given extensive mention to devices, made by many organizations, which are used in combination with its own instruments. The book

is replete with known research and analytical instrumentation uses. A third section reviews research apparatus components such as converters, balancing motors and servo amplifiers which constitute integral operating parts of research and analytical apparatus. Brown Instruments division, Minneapolis-Honeywell Regulator Co.

(20) Steel Industry Ram Trucks

A booklet is available describing a huge ram truck which was developed for the steel industry. This truck has a capacity of 80,000 lb, a lifting height of 91 in., and a turning radius of 168 in. It is powered by a 165 hp diesel engine. Yale and Towne Mfg. Co.

(21) Diesel Engines

Baldwin Series 700 diesel engines are described in a new bulletin just issued. These engines are four-cycle with a 17-in. bore, 20-in. stroke, and a speed range from 257 to 375 rpm. They have hp ratings ranging from 710 hp for 6-cylinder, normally aspirated, to 2080 hp for 8-cylinder, supercharged engines. Chief use is in generator drive for electric power supply, pumping on oil or gas lines, and other stationary power services. Baldwin-Lima-Hamilton Corp.

(22) Materials Handling Data

Among the new materials handling literature available is an accessory data sheet on the Towmotor ram, a device for handling all types of "open-center" loads—such as coils of wire, rod or strip; reels of wire and cable; large pipe and tile; rolls of paper and felt; wheel castings; and many similar materials with open centers. The ram accessory is controlled by the standard lifting and tilting mechanisms of a Towmotor fork lift truck. (AD-6) Towmotor Corp.

(23) Lorain Cranes

A new bulletin, covering the application of Lorain cranes to industrial material handling, has just been produced. This 20-page book contains over 50 illustrations showing Lorains on-the-job in many types of industries, handling many types of material. Rubber-tire "Moto-Cranes" and self-propelled Lorains and crawler mounted models are shown working in many types of industry. No product description is included, every page being filled with ideas on outdoor material handling. Thew Shovel Co.

(24) Car Shaker

A car shaker for unloading granular material from hopper-bottom gondola cars is described in a new bulletin just released. Construction features of the shaker are given along with specifications and a cross section through the vibrating mechanism. The shaker, designed to save time and money and to eliminate danger to operating personnel, has applications in power houses, steel mills, coke plants, coal mines and docks, foundries, and many other manufacturing plants. (07B7221A) Allis-Chalmers Manufacturing Co.

(25) RLM Check List

Publication of a new, four-page RLM bulletin containing a complete listing of all RLM manufacturers and the RLM-certified lighting equipment made by each, is announced. Described as "an indispensable aid to everyone who buys, sells, recommends or specifies industrial lighting equipment," copies of this new bulletin are available without charge from the Institute to industrial executives concerned with the specification, selection or installation of lighting equipment. This bulletin was issued to serve as an important aid in the procurement of lighting equipment that meets nationally-recognized standards of quality, and thus assure the user of one of the essentials to the success of a planned lighting program. Feature of the new bulletin is a well-organized, easy-to-use chart, which enables the user to quickly determine: (1) whether or not a certain size and type of lighting unit is RLM-certified; (2) the names of all manufacturers who make RLM-labeled units of the type and size desired; and (3) those lighting units not yet certified but in the process of being inspected and tested by the Electrical Testing Laboratories. (1050) RLM Standards Institute.

(26) 75 Years Lubrication Experience

A new 24-page brochure commemorating the company's 75th anniversary has been published by Brooks Oil Co. Combining both technical data and historical information about the company, this booklet traces Brooks' history from its beginning as a lamp oil producer to its position today as one of the largest compounders of industrial lubricants. Included in the technical section are details on Brooks Leadolene, Klingfast and Roll Oil F. Over two dozen case histories are cited which indicate how Brooks lead-base lubricants have compared with other products on such applications as open and enclosed gears, corrosion protection, rolling mills, circulating systems, bearings, leaking gear cases, railroad switchplates and track curves, gear reductions and wire drawing machines.

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ITEM	COMPANY	BULLETIN	DESCRIPTION
50	AIR REDUCTION SALES CO.		Folder available on oxygen in the electric furnace.
51	BAILEY METER CO.	BULLETIN 230-C	Gives the full story on the Bailey pyrotron resistance thermometer.
52	BEDFORD FOUNDRY AND MACHINE CO.		Catalog available on Bedford cranes.
53	BLOOM ENGINEERING CO., INC.	BULLETIN 2183	Describes Bloom Ka-Weld precast, reinforced pipe insulation.
54	BROOKS OIL CO.		24-page booklet describes the business policies and background of Brooks Oil Co.
55	BROWNING AND CO., INC., VICTOR R.	BULLETIN "E"	Describes Browning mill type cranes.
56	CITIES SERVICE OIL CO.		Bulletin available on combustion control for industry.
57	CLEVELAND WORM AND GEAR CO.		Catalog available on worm-gearing.
58	COLUMBIA ELECTRIC MANUFACTURING CO.		Bulletins give the facts on Columbia motor generators.
59	ELECTRIC CONTROLLER AND MANUFACTURING CO.	BULLETIN 942-A	Describes EC&M tab weld plate resistors.
60	ELECTRIC STORAGE BATTERY CO.		Catalog contains latest developments in materials handling and shows actual cast histories.
61	ELLIOTT CO., CROCKER-WHEELER DIVISION	BULLETIN SL620-1A	Explains the exclusive features that give the C-W 600 series mill motor extra power.
62	FURNACE ENGINEERS, INC.		Bulletin tells about F.E.I. service, complete from plan to production.
63	GENERAL ELECTRIC CO.	BULLETIN GEA-4654	Gives a detailed description on G-E MD-600 d-c mill motors.
64	HARNISCHFEGER CORP.	BULLETIN C-39	Describes P&H magnetorque control.
65	HAUCK MANUFACTURING CO.		Four catalogs available telling how to improve operation of furnaces, ovens, heaters and boilers.
66	HOMESTEAD VALVE MANUFACTURING CO.	REFERENCE BOOK NO. 39-3	Complete facts available on Homestead lever-seald valves.
67	HUNT AND SON, INC., C. B.	BULLETIN 104-C	Gives full details and prices on Hunt valve couplings.
68	INDUSTRIAL GEAR MANUFACTURING CO.		Pictorial trip through the Industrial Gear plant is available.
69	JONES FOUNDRY AND MACHINE CO., W. A.	CATALOG 70	Describes herringbone speed reducers.
70	KOPPERS CO., INC.		Catalog gives detailed descriptions, engineering drawings, capacity tables and photographs.
71	LINTERN CORP.	BULLETIN AC-149	Gives further data on Lintern aire-rectifier.
72	MAGOR CAR CORP.	BULLETIN DS-102	Tells the full story of Magor air dump cars.
73	MEDART CO.		Catalogs available on Medart cold finishing machines.
74	METAL AND THERMIT CORP.		Descriptive bulletin available on thermit welding.
75	MINNEAPOLIS-HONEYWELL REGULATOR CO. INDUSTRIAL DIVISION		Catalog gives complete information on the Electr-O-Line.
76	OAKITE PRODUCTS, INC.	FOLDER F7993	Tells about Oakite's new pre-paint cleaner.
77	PITTSBURGH LECTROMELT FURNACE CORP.	BULLETIN 7	Gives further data on lectromelt furnaces.
78	POOLE FOUNDRY AND MACHINE CO.		Catalog available on flexible couplings.
79	RELIANCE ELECTRIC AND ENGINEERING CO.	BULLETIN C-2001	Contains complete data on type "T" heavy-duty d-c motors.
80	SQUARE D CO.	BULLETIN 3100	Describes Square D's new safety switches.
81	TAYLOR SONS CO., CHAS.	BULLETIN 507	Gives complete description of properties of Tayco-40 silica cement.
82	TRUFLO FAN CO.		Illustrated literature available on Truflo fans.
83	WAGNER ELECTRIC CORP.	BULLETIN MU-131	Gives full information on the proper lubrication of electric motors.
84	MACKINTOSH-HEMPHILL CO.	BULLETIN 2175	Tells a more complete story of the capabilities and construction features of Mack-Hemp rotary straighteners.

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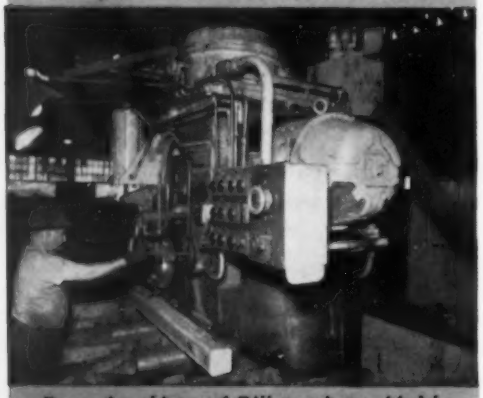

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MATERIALS HANDLING DIVISION

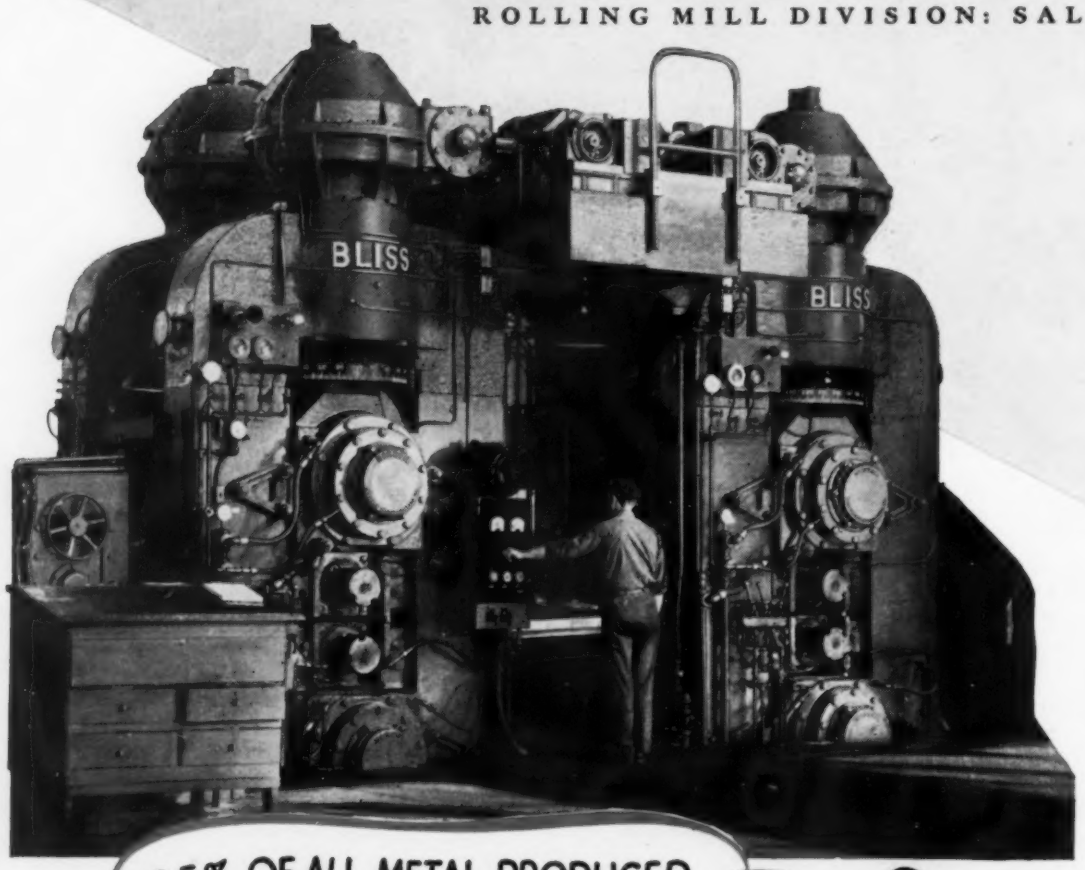
At Western Brass Mills, too,

One hundred mill runs daily to produce "tailormade" brass, copper, bronze and nickel alloy sheet and strip—that's the job assigned to rugged Bliss four-high mills at Western Brass Mills. Equipped with precision controls and adjustments to speed changeovers, Bliss mills work round the clock at Western plants in East Alton, Illinois and New Haven, Connecticut, delivering smooth-surfaced sheet and strip, true to gauge.

Performance-tested material-handling devices specially engineered by Bliss for Western Brass Mills, a division of Olin Industries, Inc., include pay-off reels, coil entry conveyors, sticker guides, tension reels, roller conveyors, Billy rolls, coil hoists and many others.

Your metal production, ferrous or non-ferrous, may benefit from new Bliss equipment—rolling mills and accessories, hot or cold. There's a good chance that Bliss engineers, who created many of the metal-producing industry's "firsts," will have the right answer for you.

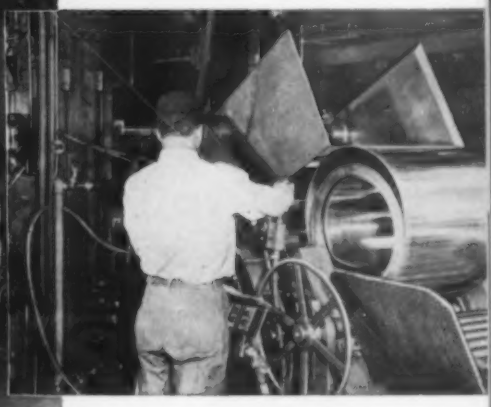
E. W. BLISS COMPANY • ***General Office:*** **CANTON, O.**
ROLLING MILL DIVISION: SALEM, OHIO

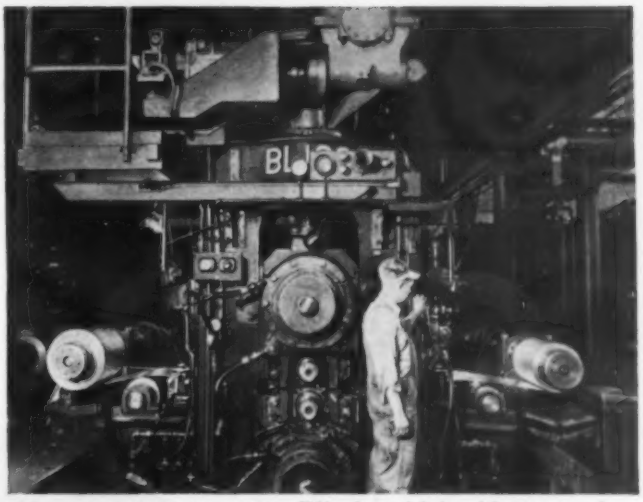


95% OF ALL METAL PRODUCED HERE AT EAST ALTON PASSES THROUGH THIS TANDEM MILL

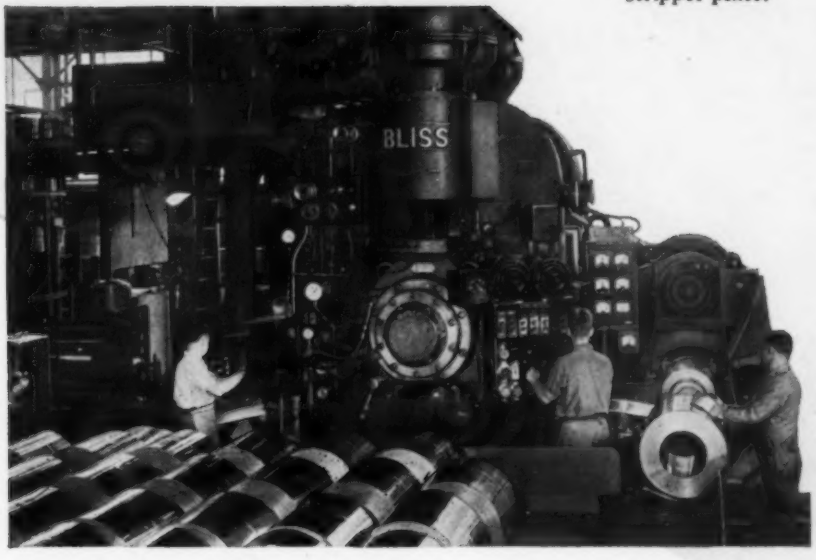
Bliss Meets Exacting Standards

Bliss Coiler coils metal on the *first* pass at .365".





Reversing finishing mill—Bliss four-high with two tension reels, Billy rolls, coil hoists with V-type conveyor rolls and stripper plate.



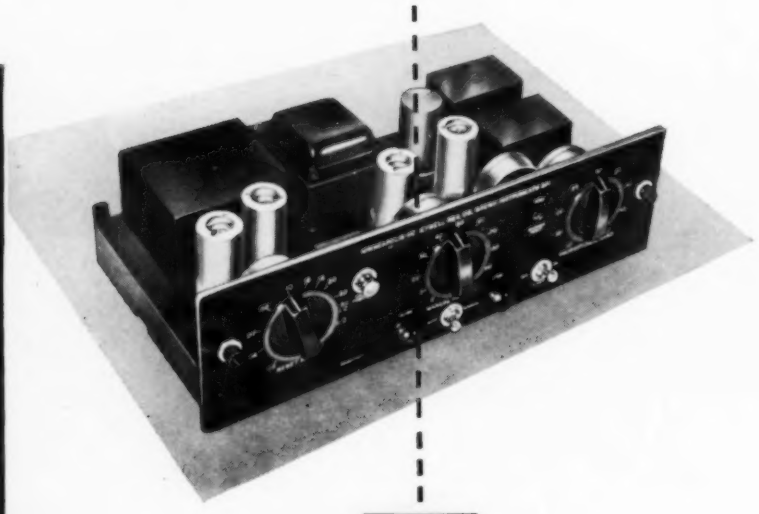
Finish rolling brass strip—this Bliss four-high mill 12" x 34" x 34" has pay-off reel (left) and tension reel (right), V-type roller conveyor and coil transfer.

Tension reel with belt wrapper for heavy and light gauge coils illustrates equipment for efficient handling.

YOU'LL GET ACCURACY

plus SIMPLICITY

BROWN INSTRUMENTATION IS THE *Plus-Factor*



WITH THE

Electr-O-Line

ELECTRIC PROPORTIONAL CONTROL RELAY

Check These Unique Features!

- √ *Control adjustments are completely independent, making "tuning in" a process very simple.*
- √ *Manual control may be accomplished from the relay.*
- √ *Plug-in chassis simplifies wiring and servicing.*
- √ *Design is completely electronic, has no motor driven resistors.*
- √ *Can be used with a variety of instrument slidewire resistance values.*
- √ *Compactness and integral mounting permit the placing of two instruments with relays on one panel.*
- √ *Has widest range of control adjustments obtainable.*

Write for Catalog!

Now YOU can attain the desired degree of accuracy dictated by your process . . . your product. The *Electr-O-Line* with automatic reset makes it possible . . . delivers a steady modulated heat input . . . in a unit of simplified design and construction that adds new compactness and convenience to precise proportional control. It may be used as an integral part of any *ElectroniK* electric proportional controller, or as a separate element for modernizing existing installations.

A check of the list of its unique features will prompt you to call in your local Honeywell engineer for a discussion of how the *Electr-O-Line* can help improve your process. Branch offices in more than 80 principal cities of the United States, Canada and throughout the world. MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, 4464 Wayne Ave., Philadelphia 44, Pa.

MINNEAPOLIS **Honeywell**

BROWN INSTRUMENTS

Specify N-B-M BRONZE CASTINGS

for higher steel mill production...lower costs!

Custom-engineered alloys — plus close foundry control — insures longer, more economical service

Longer life means less down-time . . . actual dollar-savings in the operating costs of your mill. You specify longer life when you specify N-B-M Bronze Castings . . . because of this important 3-Way Service offered by National Bearing Division:

Research . . . that in case after case has developed new alloys that roll up new tonnage records.

Engineering . . . that results in new and better designs to help solve old maintenance and production problems.

Facilities . . . for close foundry control that insures sound, dense castings—as-cast or machined to any degree of finish you desire.

From huge screw-down nuts to a complete line of Cored and Solid Bars for small bearings and bushings, put this 3-Way Service to work in your mill!

All types of Manganese, Aluminum, Nickel and High Tensile Bronze Alloys ...produced to your specifications or from our own service-proved formulas

AMERICAN Brake Shoe COMPANY

NATIONAL BEARING DIVISION

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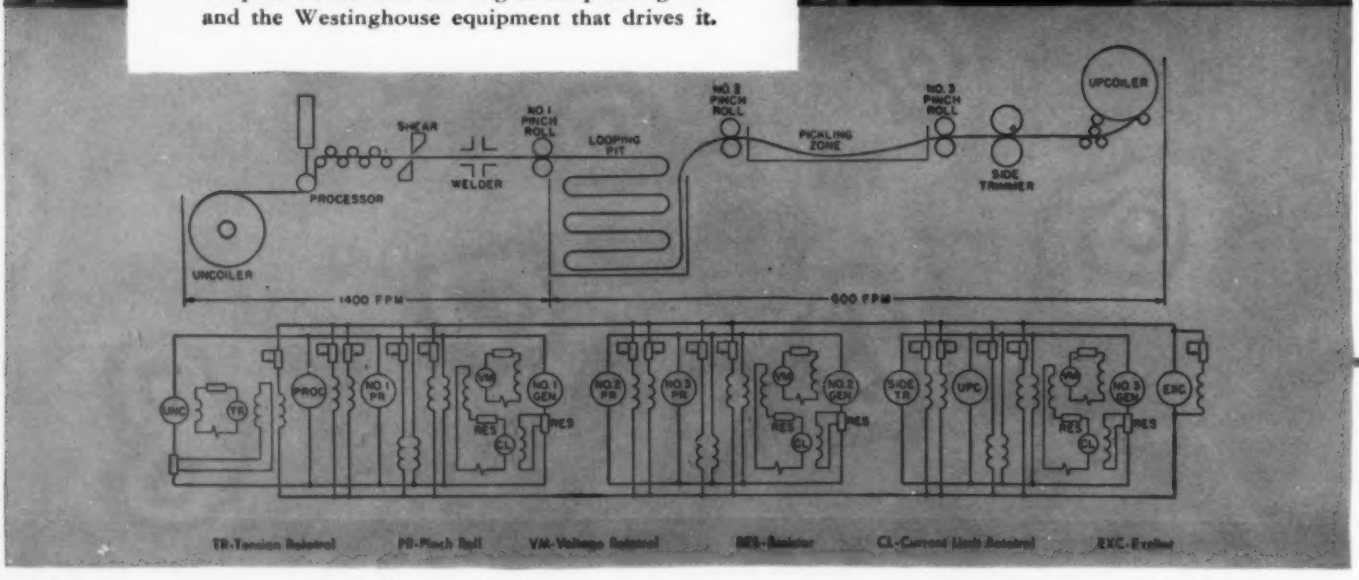
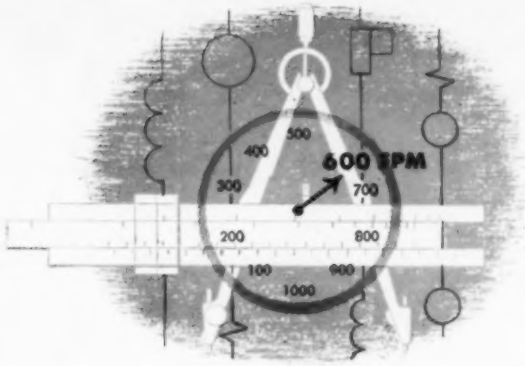
YOU CAN BE SURE.. IF IT'S
Westinghouse

Looping pit in the world's fastest strip pickling line, and shown beyond it, the pickling tanks.

• • •

Simplified schematic drawing of the pickling line and the Westinghouse equipment that drives it.





The world's fastest strip pickler

CAN YOUR NEXT JOB USE THE KNOW-HOW THAT ENGINEERED ITS ELECTRIC DRIVE?

You may not be considering strip pickling lines right now. But the know-how that engineered the drive for this one *can* make your next installation a better one, whatever it may be. Here's how it met this problem.

The mill wanted a line to turn out 50,000 tons per month in 30,000-lb. coils. That meant an exit speed around 600 fpm, *20% faster than any other line in existence.* Four or five hot-rolled coils would be fed in for each emerging coil. So to allow for time required in shearing, welding, and trimming the ends, the entry speed had to be 1400 fpm.

So these were the basic requirements: 1. Build a drive that keeps speed *constant* in the pickling zone to keep quality uniform. 2. Maintain constant rates of *acceleration and deceleration* in the entry side so that a high-production, continuous operating cycle could be established. 3. Provide *fast* acceleration and deceleration to minimize idle time at the entry end.

Westinghouse answered the needs with a three-stage adjustable-voltage drive regulated by ROTOTROL, the master electrical intelligence. The first-stage motors, supplied by one M-G set, drive the uncoiler, scale-breaker, shear, welder, trimmer, and pinch roll—the strip passing through each in turn. Strip then enters the looping pit. The second-stage motors, supplied by a second M-G set, drive the pinch rolls on either side of the pickle tank. The third stage drives the exit end of the line: a second shear, side trimmer, oiling rolls and final coiler.

The three-stage drive gives the needed speed differential AND speed control. Moreover the line is easy to operate since all operations, including shearing, welding, and trimming are at least semiautomatic.

It took the combined efforts of the mill, the equipment builders and Westinghouse to engineer this line. The electric drive is a result of this company's lifetime of intimate contact with the steel industry. And it can pay off on your next job. Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pa. J-94845

Westinghouse

EQUIPMENT FOR THE STEEL INDUSTRY

"Job-Engineered" means tailored to your crane needs

When you buy a crane, you want dependable service for many years to come. Your P&H "Job Engineered" crane will be built to meet your requirements to insure dependability . . . ample reserve capacity . . . adequate service factor . . . maximum safety. All P&H electrical equipment is designed and built by P&H for crane service — not adapted for it.

"Job Engineered" is an Added Value which comes with P&H's 65-year experience in crane-building — to serve your needs *exactly*.

And here's a fact worth remembering: P&H Cranes are sold and serviced by factory-trained men — not agents.

P&H Magnetorque* is the greatest advancement in AC crane control in the past 40 years. Ask about it.

*T. M. of Harnischfeger Corporation for electro-magnetic type brake.

EXCAVATORS • OVERHEAD CRANES • HOISTS • ARC WELDERS AND ELECTRODES • SOIL STABILIZERS • CRAWLER AND TRUCK CRANES • DIESEL ENGINES • CANE LOADERS PRE-ASSEMBLED HOMES

P&H

OVERHEAD CRANES

4455 West National Avenue
Milwaukee 14, Wisconsin

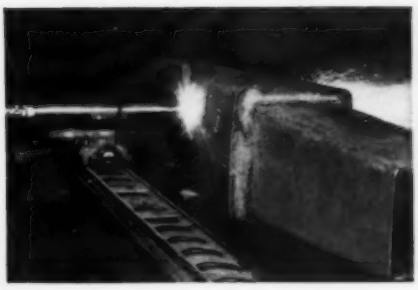
HARNISCHFEGER CORPORATION

Write for your copy of Bulletin C-39 describing P&H Magnetorque control.

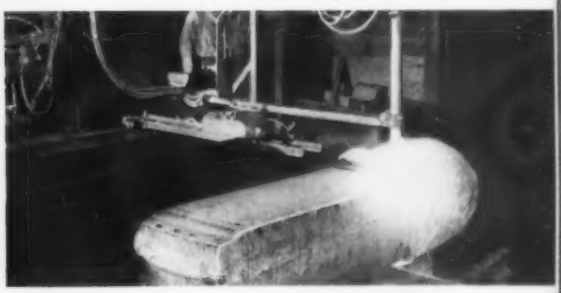
OVER 17,000 P&H CRANES SERVE AMERICAN INDUSTRY . . . FAR MORE THAN ANY OTHER

At the blast furnaces and open hearths, oxygen plays an important part. Furnace-tapping with the oxygen lance—oldest use of oxygen-cutting in steel plants—still saves time and reduces hazards.

Help on the Hot and Heavy Jobs



Ingots requiring 200 hours for mechanical "parting" have been split with the OXWELD C-45 heavy-duty blowpipe and then machined in 14 hours total time.



Cutting the hot top off this 26-inch forged slab with the C-45 blowpipe took less than 10 minutes and left the slab end square and undeformed.

The deseaming blowpipe, equipped with the OXWELD starting-rod feed, has reduced conditioning costs more than 50 per cent.

Draining furnace salamanders by oxygen-lance tapping has reduced furnace down-time more than three weeks in some steel plants.

LINDE service engineers who co-operate closely with the steel industry—have combined experience, knowledge, and practical "know-how" to help make better steel, faster, and at lower cost.

LINDE engineering service is always available to LINDE customers through the nearest LINDE office.

The terms "Linde" and "Oxweld" are registered trade-marks of Union Carbide and Carbon Corporation.

Linde

LINDE AIR PRODUCTS

A Division of Union Carbide and Carbon Corporation

30 East 42nd St., New York 17, N. Y. UCC Offices in Other Principal Cities

In Canada: DOMINION OXYGEN COMPANY, LIMITED, Toronto

Says the Superintendent of a large Process Industries Plant:

This plant's experience is typical of that of thousands of other users, and tells why Homestead Lever-Seald Valves have been first choice for more than 18 years for services where corrosive fluids, slurries, abrasives, or extremes of temperature or pressure cause ordinary valves to fail.

Homestead Lever-Seald Valves are stick-proof; require less maintenance; and the means for easy turning under all conditions, is built right into the valve. We can furnish them in stainless steel, steel, iron, brass or alloys to meet your needs; sizes 1½" to 10"; for pressures from vacuum to 1500 lbs.

Write for valve reference book
No. 39-3. No obligation.

HOMESTEAD VALVE MANUFACTURING CO.

"Serving Since 1892"

P. O. BOX 21 **CORAOPOLIS, PA.**

Oxygen cuts electric furnace melting costs over $2,000 per month

WEHR STEEL COMPANY, of Milwaukee, Wisconsin, wanted to compare the refining of acid electric steel using oxygen with that of their usual method — the use of iron ore. They hoped to reduce refining costs without affecting the quality of the finished steel.

Clarence Nolan and W. R. Lysobey, Airco Technical Sales Representatives, were called in and suggested a series of test heats using Airco oxygen. On the basis of these tests, it was found that the cost of Airco 99.5% pure oxygen is about the same as the iron ore it replaced . . . *but,* the savings in ferro manganese, heat time, electrodes and power were appreciable — amounting to more than $1.00 per ton melted on a monthly tonnage of about 2,000 tons. Furthermore, the high quality of the steel was maintained.

Additional savings were also enjoyed when the problem of handling and storing iron ore was eliminated.

The Wehr Steel Company was most pleased with these results and have adopted oxygen refining of acid electric steel as standard practice.

For technical assistance on this unique refining process or a copy of our folder "Oxygen In The Electric Furnace," please write to your nearest Airco office.

AIRCO

AIR REDUCTION

AIR REDUCTION SALES COMPANY • AIR REDUCTION MAGNOLIA COMPANY
AIR REDUCTION PACIFIC COMPANY
REPRESENTED INTERNATIONALLY BY AIRCO COMPANY INTERNATIONAL
Divisions of Air Reduction Company, Incorporated
Offices in Principal Cities

More news about AIRCO steel mill processes

ACETYLENE SMOKING ELIMINATES HYDROGEN TRACES ON STEEL SURFACE

A leading steel mill, after experimenting on more than 2,000 molds of various sizes, plans to use acetylene ingot mold smoking in all molds that will be used for the pouring of "Tool Steels", "Electric Furnace Steel", "Acid Open Hearth Steel", and "Roll Foundry Steel". They claim that steel poured in molds — *and treated in any other way than by acetylene smoking,* show traces of hydrogen in the surface of the steel.

THE ECONOMICAL WAY TO CUT HEAVY SCRAP TO CHARGING BOX SIZE

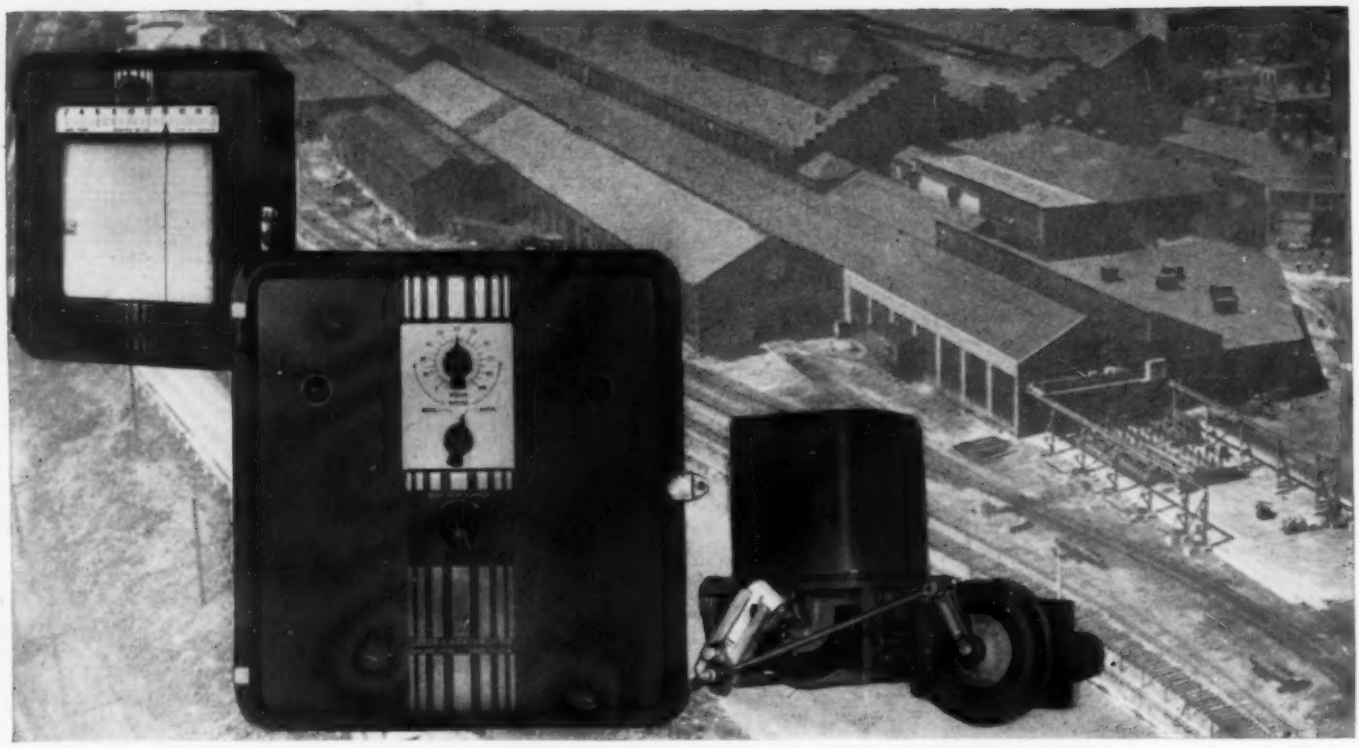
Today, Airco offers steel men outstanding oxyacetylene cutting methods for easy and economical handling of heavy scrap. Practically any heavy scrapping job can be handled . . . regardless of size, shape or location . . . with:

- **the oxyacetylene torch, plus oxygen lance.** Buttons, ingots, and similar large chunks can be cut to size in any position without initial handling.
- **machine gas cutting.** Where crane facilities are available, this set-up is ideal. All it requires is a heavy-duty cutting torch mounted on a standard Airco No. 40 Radiagraph or a Travograph.
- **the oxygen lance.** Where extremely large sections, such as open hearth spills and huge ingots are to be cut, the oxygen lance should be used.

All this is just another example of how modern Airco oxyacetylene equipment is helping steel mills slash time and costs.

★ ★ ★

Air Reduction supplies Oxygen, Acetylene and other industrial gases . . . Calcium Carbide . . . and a complete line of gas cutting machines, gas welding apparatus and supplies, plus arc welders, electrodes and accessories. Ask us about anything pertaining to gas welding and cutting, and arc welding . . . we'll be glad to help you.



Major Advance in Electric Control Increases Production From Industrial Operations

With production demands reaching toward fresh all-time highs, this new P.A.T.'50 Control comes at the ideal time to help thousands of firms increase the output of their industrial furnaces. Here's why:

This Control has something that's brand new. It acts on the *speed* of swings in furnace load, as well as on their size and permanence. Thus, if temperature changes gently, it is gently nudged back into line. But if it starts off briskly—as when the furnace door is opened—P.A.T.'50 reacts briskly. The faster the change, the further P.A.T.'50 moves the fuel valve. Then, at the instant this action begins to head off the change, the Control starts backing away. By putting on the brakes it brings temperature back in line smoothly, rapidly.

This "Rate Action" increases production because it reduces the length of time a furnace is off temperature. It means more heats per week.

P.A.T.'50 is the Only electric positioning control with Rate Action. It's a unique L&N contribution to automatic regulation.

Also, Proportioning and Reset Actions are more responsive than before. These two components have always been vital to automatic control, and of course continue so. They stop the normal, every-day temperature swings which are started by changes in the size and permanence of the furnace load.

When we gave P.A.T. its third component of rate action—and introduced it in this '50 model—we were able also to increase the sensitivity and range of adjustment of proportioning and reset components. The resulting improvement in control action shows up at all times, but especially when temperature is being stubborn—trying to edge away from the control point, or to level off incorrectly. Even without rate action, P.A.T.'50 would do a better-than-ever job. But with rate action, results are far superior to any previous electric control.

The News is in the Control Unit. Everything new in P.A.T.'50 is in the Control Unit—the device in center of above illustration which is usually mounted below the Speedomax or Micromax Recording Controller, and which links that instrument to the fuel-valve-driving mechanism. In line with our policy of making improvements readily available to users of our equipment, earlier installations of P.A.T. Control can be converted to P.A.T.'50 by replacing the Unit and making slight changes in the Controller. The new Unit is fully electronic—has no moving parts except two hermetically-sealed relays.

For complete details, contact our nearest office, or write us at 4942 Stenton Ave., Philadelphia 44, Pa.

MEASURING INSTRUMENTS · TELEMETERS · AUTOMATIC CONTROLS · HEAT-TREATING FURNACES

LEEDS & NORTHRUP CO.

Jrl. Ad ND4-33(1)

Here's the MILL MOTOR that gives you EXTRA POWER

CROCKER-WHEELER 600 SERIES Direct Current MILL MOTOR

Available for heavy duty mill and crane service in 5 to 265 horsepowers. Also available in the following modified forms—separately forced ventilated — protected self-ventilated — back geared. Bulletin SL620-1A gives details.

■ In developing this great new motor, C-W engineers have achieved a design that conforms to AISE standards, but packs *more power* into each standard size frame—as much as *33% more!*

And like a true champion, the Elliott C-W Mill Motor can take it as well as dish it out. It's more than a match for the heavy overloads, the reversing strains and the punishing continuous duty of the toughest mill service.

When you need a mill motor—whether for replacement or for new drives—it will pay you to get the motor that, size for size, gives you the most power — the Elliott C-W 600 Series.

GET FULL DETAILS IN THIS NEW BULLETIN

It explains the exclusive features that give the C-W 600 Series Mill Motor *extra power* — make it *extra easy to maintain—give it extra long life.* Write for Bulletin SL620-1A—
Address, Dept. I, Elliott Company, Jeannette, Pennsylvania.

Crocker-Wheeler AC and DC motors and generators range from 1 to 200 hp or kw. Larger Elliott motors and generators are built by the Ridgway Division in Ridgway, Pa.

CW-21

ELLIOTT COMPANY

CROCKER-WHEELER DIVISION

Ampere, N. J.

BRANCH OFFICES AND REPRESENTATIVES IN PRINCIPAL CITIES

ELLIOTT *Approved* SERVICE SHOPS COVER THE COUNTRY

GENERAL OFFICES & MAIN PLANT, JEANNETTE, PA.

You produce more tonnage with *Alliance* Charging Machines

This new Alliance OH Charging Machine is operating today in one of the nation's leading steel plants.

EXCLUSIVE WITH ALLIANCE Our new 12-ton low-type open hearth Charging Machine has spring-loaded pitman so, if the charging box pushes up on scrap in furnace, the trolley's front wheels won't lift off rails. Trolley always has sufficient tractive power to retract the peel and box from furnace. The spring-loaded pitman also prevents shock when peel is lowered to engage charging box.

EXCLUSIVE WITH ALLIANCE Bridge girders of Alliance's new Charging Machine consist of two wide, flanged I-beams welded to form a box section. Between webs of this box section diaphragms are welded at intervals of 3 ft., plus other welded reinforcements.

EXCLUSIVE WITH ALLIANCE Machinery deck plate extending full length of bridge between main girder and outrigger girder reinforces main girder laterally and keeps Charging Machine square under all operating conditions.

EXCLUSIVE WITH ALLIANCE Stabilized, shock-absorbing wheels operate at rear end of trolley. Two of these wheels engage the lower rail; two adjacent wheels engage the upper rail. Wheels are held in contact with respective rails by means of springs. When load is engaged and disengaged at end of the peel, shock which normally occurs at end of trolley is absorbed by the spring suspension. Consequently, shock to the operator is minimized.

EXCLUSIVE WITH ALLIANCE On eight-wheel bridges, the four trucks located at corners of the bridge are equalized to accommodate any irregularities in the track.

EXCLUSIVE WITH ALLIANCE The new hydraulic lock rod gives operator finger-tip control and eliminates laborious work ordinarily connected with lock rod operation.

EXCLUSIVE WITH ALLIANCE All gears (including track wheel gears) are fully enclosed and run in oil.

This Charging Machine was built by the world's largest builders of the world's largest cranes. Alliance leads the field with its heavy material-handling equipment. Contact Alliance for your requirements.

THE ALLIANCE MACHINE COMPANY

MAIN OFFICE
ALLIANCE, OHIO • PITTSBURGH OFFICE **1622 OLIVER BUILDING, PITTSBURGH, PA.**

LADLE CRANES • GANTRY CRANES • FORGING MANIPULATORS • SOAKING PIT CRANES • STRIPPER CRANES • SLAB AND BILLET CHARGING MACHINES • OPEN HEARTH CHARGING MACHINES • SPECIAL MILL MACHINERY • STRUCTURAL FABRICATION

production-line straightening

controlled-quality finishing

of metal pipes and tubes with

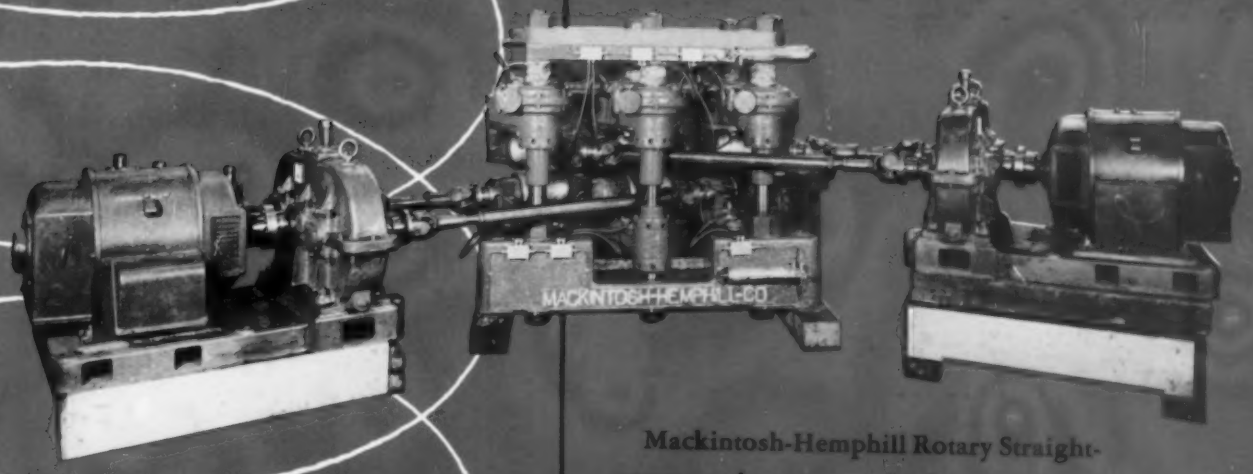
mack-hemp *rotary straighteners*

That's the story you'll hear thruout the metal working industry because Mack-Hemp Rotary Straighteners are used by manufacturers and fabricators of pipes and tubes ranging in size from

⅛" O.D. to 15" O.D.

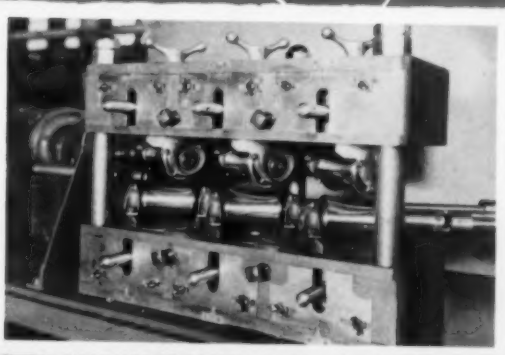
Most important fact about Mack-Hemp Straighteners, regardless of size, is that they deliver consumer-acceptable products, straightened and finished from end to end.

These modern productioneering tools are widely used in finishing cut-length material such as stainless instrument tubing, aluminum aerial stock, copper automotive fuel lines, aviation brake tubing, Inconel heating element tubing, standard welded pipe, heavy-wall seamless alloy tubes, large diameter wrought-iron pipe, and in many other ferrous and non-ferrous applications.



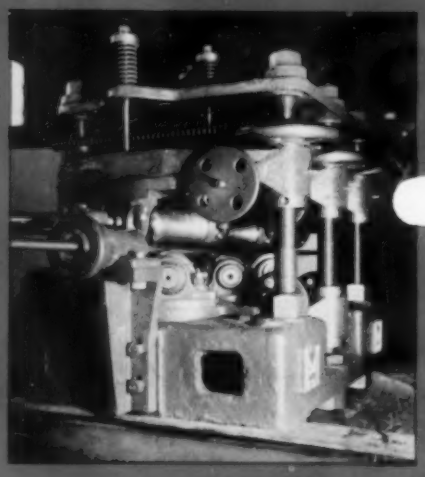
Mackintosh-Hemphill Rotary Straighteners employ a patented roll arrangement with an offset cross roll pass between two fixed cross roll passes. This feature eliminates supporting guides for the material and increases the productive life of the rolls.

Model AXY, for high-speed production line straightening. Straightens ⅛"-⅜" tubing at 350 feet per minute.



MORE ON M-H

As a result, Mack-Hemp Rotary Straighteners are high-speed precision tools which



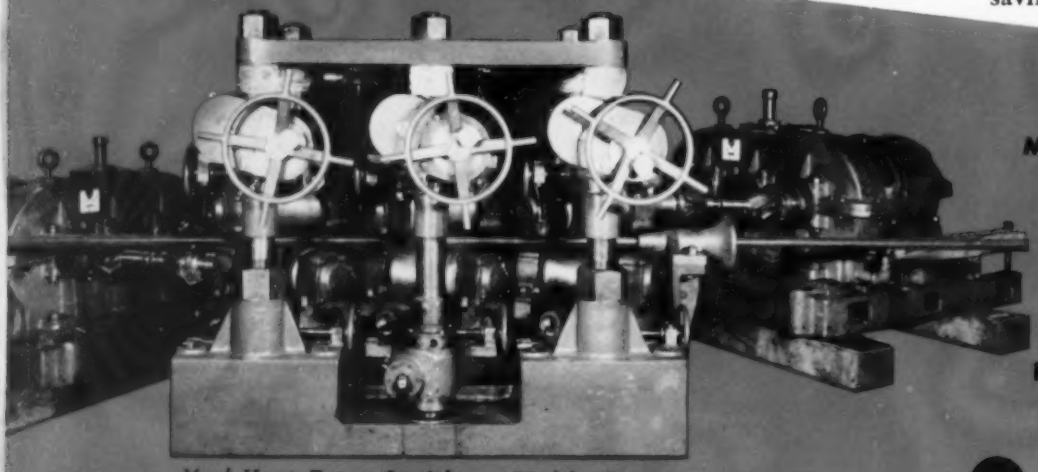
AX Model works for tube fabricating company, straightens ¼"-1¼" tubing at 350 ft/min.

straighten to precision tolerances, end-to-end

finish without leaving spiral scores, cuts, or rub marks on exterior surfaces

remove end bends from cut-length stock

increase efficiency of straightening operations by saving time and improving surface finish



Mack-Hemp Rotary Straightener Model AO accommodates ⅛"-2½" pipe at 500 ft/min rate.

Mack-Hemp Rotary Straighteners apply the pressures necessary for straightening in an unusual and effective way. The roll arrangement, which is basic in all sizes, is the construction feature which

reduces setting-up time

reduces roll wear

eliminates large straightener-roll inventories

cuts operating power costs

A more complete story of the capabilities and construction features of Mack-Hemp Rotary Straighteners is told in the new bulletin 2175—write for a copy, and for a list of users of M-H Straighteners in the size required for your operations. Address Machinery Department, Mackintosh-Hemphill Company, Bingham & 9th Streets, Pittsburgh 3, Pennsylvania.

MACKINTOSH-HEMPHILL CO.

PITTSBURGH and MIDLAND, PENNSYLVANIA

MACKINTOSH-HEMPHILL PRODUCTS INCLUDE: ROLLS . . . STEEL AND SPECIAL ALLOY CASTINGS . . . COMPLETELY INTEGRATED STRIP MILLS . . . HEAVY DUTY ENGINE LATHES . . . THE NEW MACKINTOSH ROTARY STRAIGHTENERS . . . IMPROVED JOHNSTON PATENTED CORRUGATED CINDER POTS AND SLAG-HANDLING EQUIPMENT . . . SHAPE STRAIGHTENERS . . . END-THRUST BEARINGS . . . SHEARS . . . LEVELLERS.

Four ways to cut ingot car maintenance costs . . . with TIMKEN® bearings

WHICHEVER of these typical Timken® bearing ingot car applications you choose, you can be sure of extra operating advantages and a minimum of maintenance. Timken bearings keep cars rolling smoothly, reduce starting resistance 88% of that of friction bearings. Thrust washers or thrust bearings are unnecessary. Axle wear is eliminated. Lubricants are retained longer.

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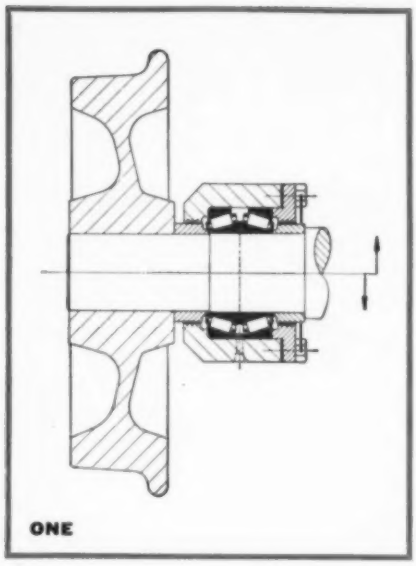
The many advantages of Timken bearings have been proved time and time again in all types of railroad applications. No other bearing has so much to offer . . . no other bearing is so fully proved. Our Engineering Staff will be glad to help you solve your bearing problem. Write The Timken Roller Bearing Company, Canton 6, Ohio. Cable address, "TIMROSCO".

This symbol on a product means its bearings are the best



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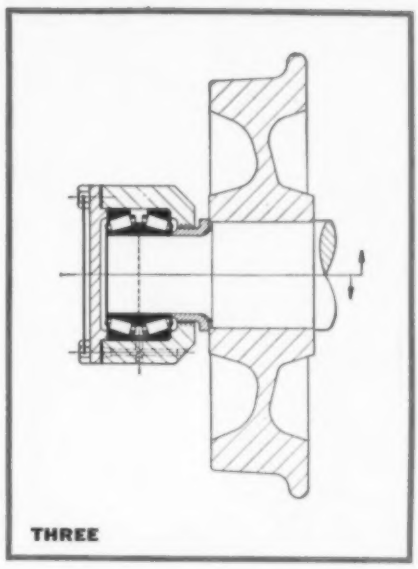

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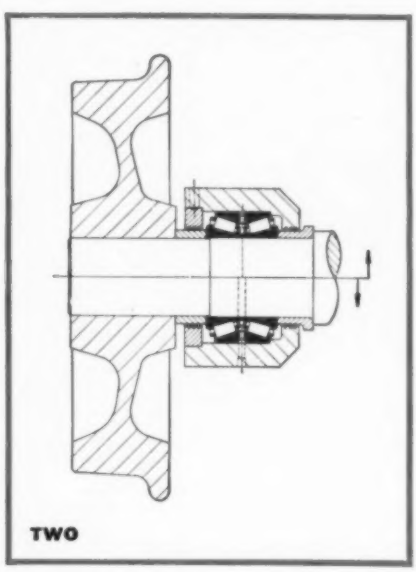

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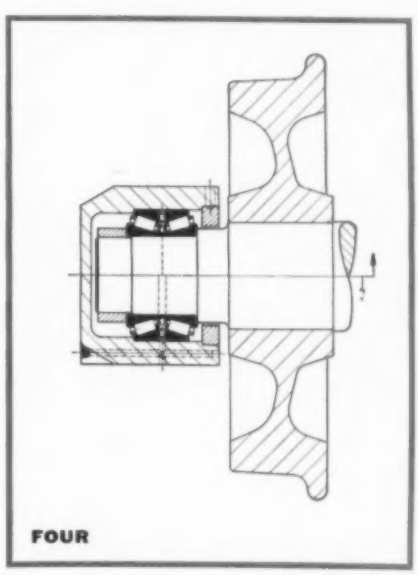

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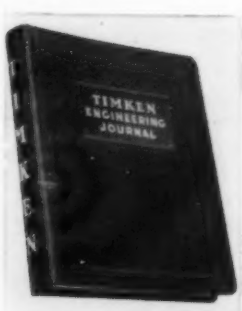

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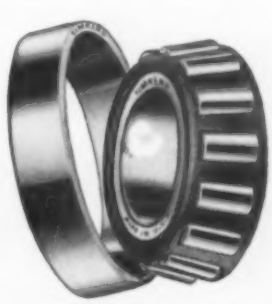

NOT JUST A BALL ○ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▭ BEARING TAKES RADIAL ⇕ AND THRUST →◎← LOADS OR ANY COMBINATION →✳←

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Here are a few examples of CLARK Mill Controls.

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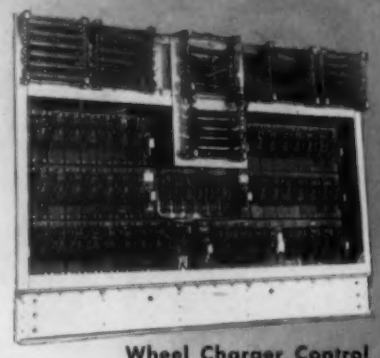
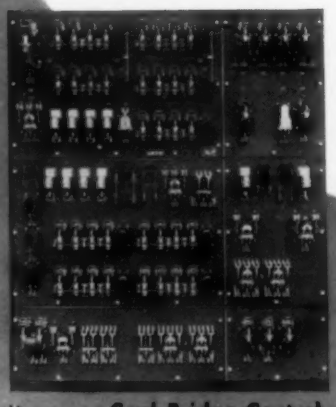
In steel and non-ferrous mills all over the country CLARK engineered controls provide reliable, low-maintenance trouble-free operations.

From ore to finished products CLARK controls help speed production.

Make your next job CLARK CONTROLLED



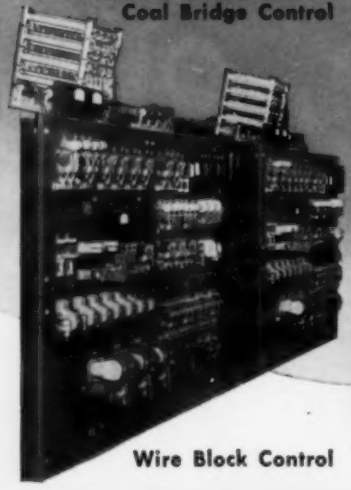
Wheel Charger Control



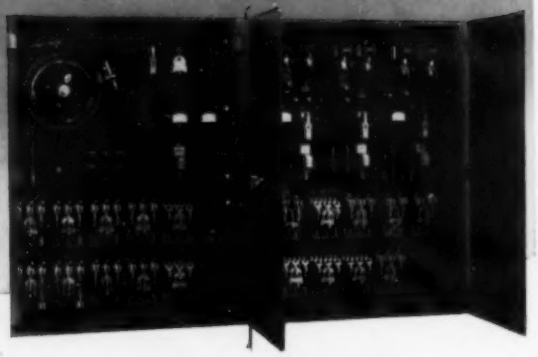
Coal Bridge Control

Cold Strip Mill Cutting Up Line Control

Coke Pusher Control



Wire Block Control



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Merged for better service to you

Two substantial leaders in service to the metals industry throughout the free world . . . Edgar E. Brosius Company, Inc. and Salem Engineering Company, have now joined hands in order to be of greater service to their customers. The large and capable consulting and industrial furnace designing staff of Salem is now immeasurably strengthened by the mechanical equipment manufacturing capacity of Brosius, whereas, the blast furnace and steel plant machinery designers at Brosius have many brilliant new partners to assist them. So apropos is this merger of talent that you can now call upon new Salem-Brosius, Inc. with complete confidence whether your needs include the smallest of furnaces or the construction of the largest plant projects.

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Affiliates: Brosius Division, Pittsburgh 15, Pa.; Salem Engineering Division, Salem, Ohio;
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WHICH TOWER IS THE MOST IMPORTANT?

All four towers of the bridge are necessary, of course; none is of minor importance. De Laval engineers are skilled in seeing that all four fundamentals of steel mill lubrication are built into every Lubrication System to assure dependable lubrication performance at all times.

Sometimes the mill requirements dictate a completely engineered system, designed just for that mill. Sometimes, as in the case of smaller mills, a De Laval Unilube System is all that is needed. The Unilube is a self-contained unit with circulating capacities of 1 to 40 gpm.

The four fundamentals of De Laval design are:

1 PURIFICATION OF LUBRICATING OIL

De Laval Oil Purifiers, furnished as part of the design where possible, are permanently piped to the system to permit centrifugal by-pass purification of the lubricant in service. The Purifiers remove water and fine solid contaminants.

2 PROPER SELECTION OF PIPE SIZE

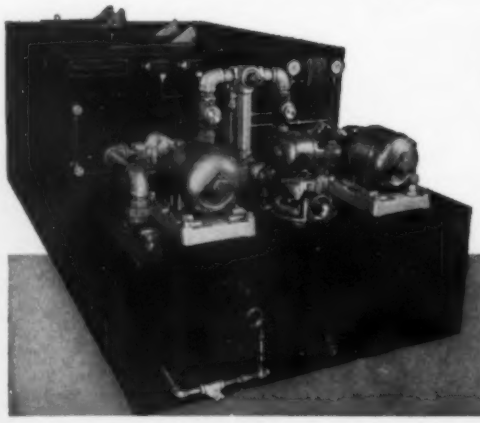
The proper selection of pipe size is important to provide efficient lubrication. All De Laval Systems are designed to keep the pressure drop due to line friction at a minimum, and to insure a streamline flow.

3 CORRECT METERING OF LUBRICANT

De Laval Systems stress supplying each bearing and gear mesh point with exactly the right amount of lubricant. A constant streamline flow of lubricant in the correct quantity and pressure must be maintained at all times.

4 EFFICIENT TEMPERATURE CONTROL

De Laval Systems incorporate a constant control of the lubricant temperature both winter and summer. By the use of efficient heating or cooling facilities, a continuous flow of lubricant at the correct temperature and viscosity is maintained.



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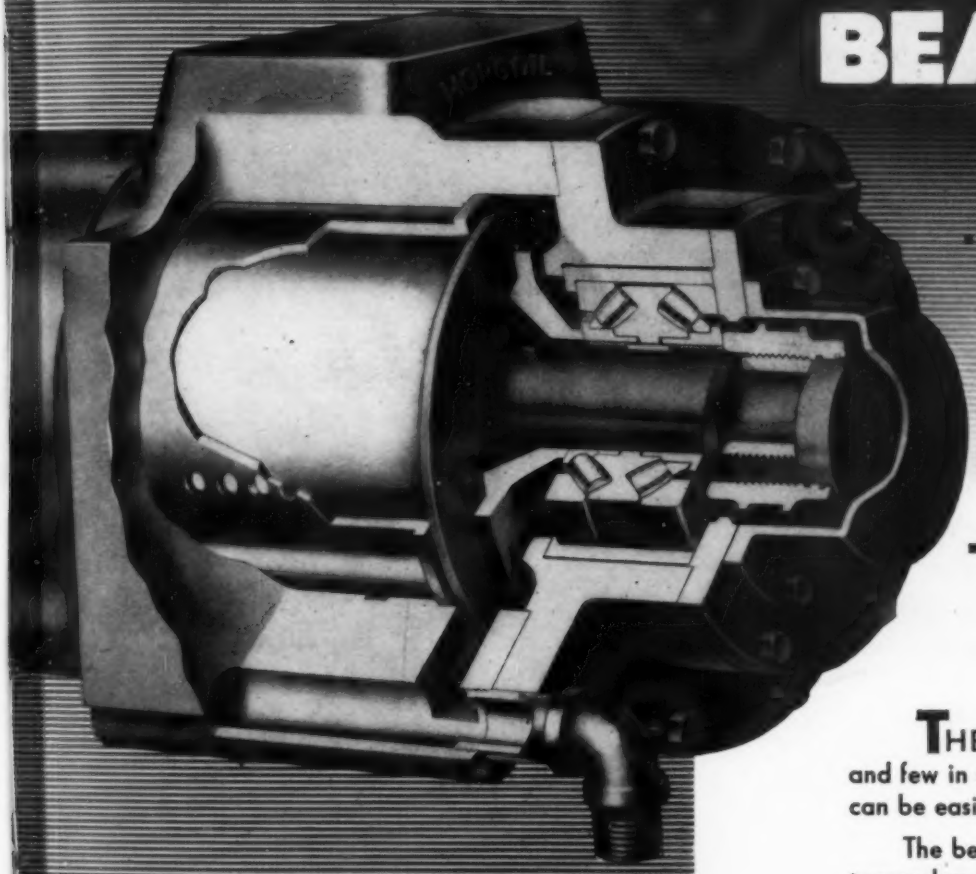
ENGINEERED SYSTEMS

MORGOIL

ROLL NECK BEARINGS



....insure accurate products

...last a long time

....require little maintenance

THE essential parts of the bearing are simple and few in number . . . making a compact unit that can be easily removed from the roll neck.

The bearing operates on a film of oil which has tremendous load carrying capacity, hence there is no wear. The load is distributed over a large area with no points of concentration, so fatigue failures of bearing parts are unknown.

The operation of a bearing under hydro-dynamic lubrication results in an extremely low coefficient of friction and low power requirements.

The absence of wear in the radial bearing and the close control of axial roll movement afforded by the thrust bearing, permits the rolling of both sheets and sectional products within extremely close tolerances.

May we tell you more about the success of Morgoils on new or existing mills?

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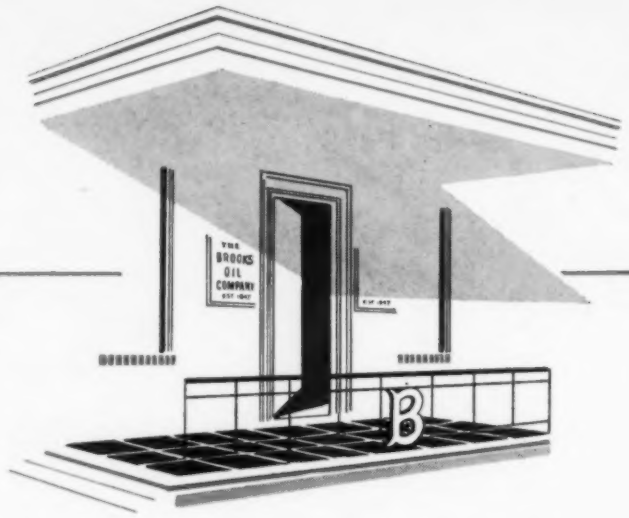

Brooks says Thanks to You on our

75th Anniversary

Our steady growth is due to satisfied customers whose lubrication problems we have solved with LEADOLENE*

Through constant research and sound expansion policies Brooks has grown from a humble beginning to a position today as one of the country's major compounders of industrial lubricants. This history of three-quarters of a century of progress we owe to the good will of our customers. In recent years, when expansion has been particularly extensive, the greatest part of our growth has come from existing customers who have been well satisfied with the exceptional service of Brooks extreme pressure lubricants. By devoting 100% of our research, engineering and production facilities to only one thing—the compounding of industrial lubricants—we hope to continue supplying engineering service and lubricants for the tough jobs in industry.

Write . . . for this new 24-page booklet which describes the business policies and background of our company, and includes many case histories which show how Brooks extreme pressure lubricants are serving industry.

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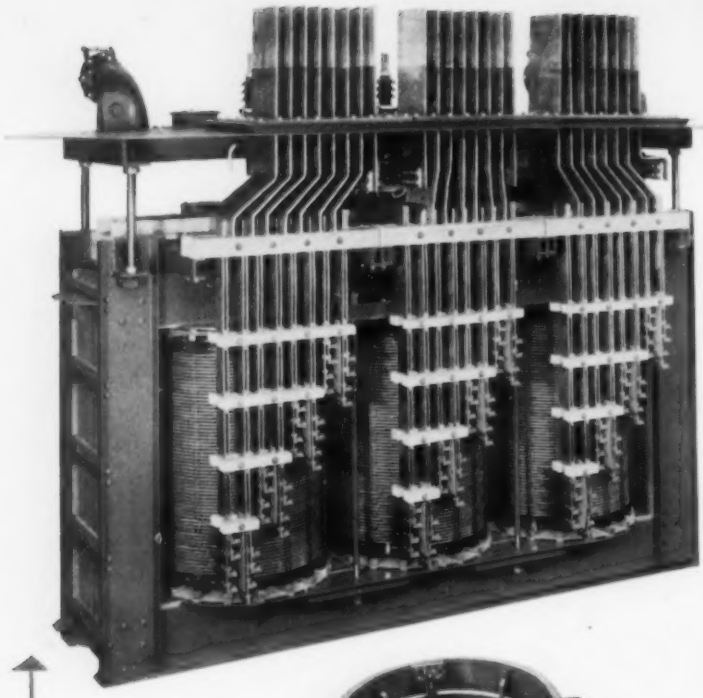
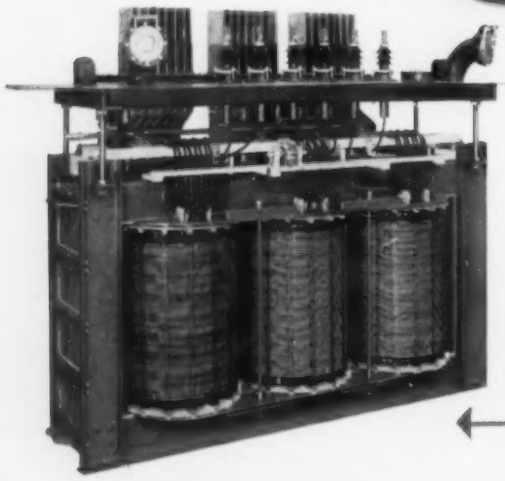


Low Voltage side. Note arrangement of bus bars.

12,000 Kva Furnace Transformer, 3 Phase, 60 Cycles, Water Cooled. High Voltage, 12,000 Volts. Low Voltage ranges from 375 down to 200 Volts, or full capacity. Maximum Low Voltage line current — 34,600 Amperes. High Voltage brought out with six bushings for star connection to obtain a lower range of low voltages.

Interior of tank showing arrangement of copper water cooling tubes.



High Voltage side. Pennsylvania's 3 Phase straight line tap changer mounted above core and coil unit can be quickly and easily inspected and maintained through cover manholes.

Recently installed 12,000 KVA Furnace Transformer raises total of PENNSYLVANIA FURNACE TRANSFORMERS in service to 1¼ MILLION KVA

When this 12,000 Kva Furnace Transformer was put into service, it brought the total installed Kva of Pennsylvania Furnace Transformers to over 1¼ million Kva.

The successful operation of Pennsylvania Furnace Transformers and their industry-wide acceptance indicate that Pennsylvania engineers fully understand the problems of electric furnaces and their relation to furnace transformers.

Pennsylvania TRANSFORMERS

Pennsylvania TRANSFORMER COMPANY

CANONSBURG, PENNA. • Greater Pittsburgh District

SILENTLY, but ruthlessly *(even as you are reading this)* rust is gnawing away at machines, tanks, fences, pipes, fire escapes, metal sash, stacks —every rustable metal—inside and outdoors!

To protect your investment — to keep every possible pound of new steel for the defense program — to make all rustable metal surfaces last longer—*adopt rust control with RUST-OLEUM as an important part of your maintenance program.*

RUST-OLEUM stops rust! Its tough, pliable, rust-resisting film gives excellent protection that prevents rust losses under many difficult rust-producing conditions.

RUST-OLEUM can be applied *even* over rusted sufaces. It is not necessary to remove all the rust. Just use wire brush and sharp scraper to remove rust scale and loose rust. Economical and easy to use because no sand blasting or chemical pre-cleaning is required.

RUST-OLEUM can be obtained promptly from Industrial Distributors' stocks in principal cities of the United States and Canada. Anticipate your needs and order now! For complete catalog see *Sweet's*, which also lists your nearest source of supply, or write on your company's letterhead for full information.

RUST-OLEUM CORPORATION
2442 Oakton Street, Evanston, Illinois

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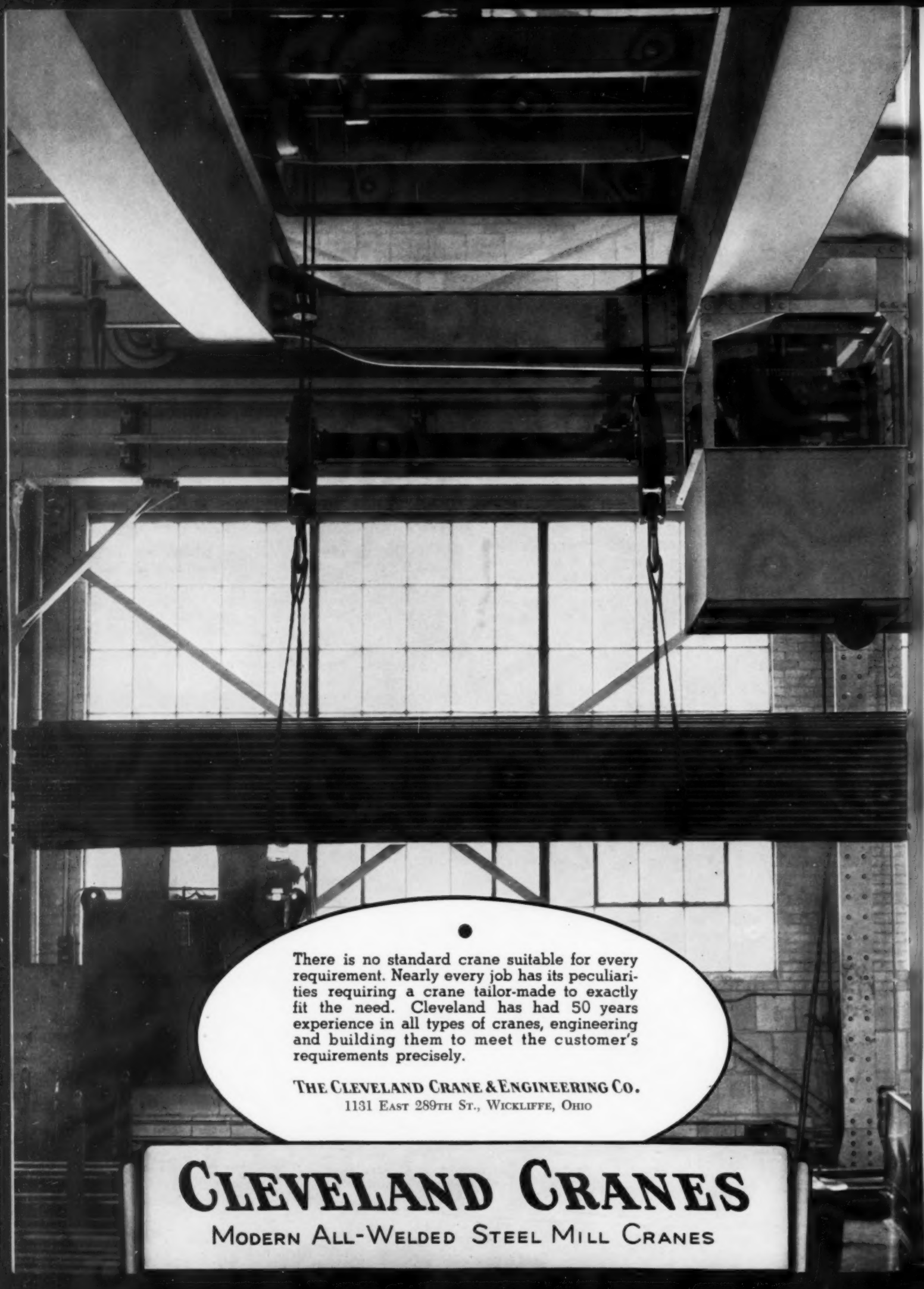
Stops Rust

Beautifies AS IT PROTECTS

Available in many **COLORS,** aluminum and white.



There is no standard crane suitable for every requirement. Nearly every job has its peculiarities requiring a crane tailor-made to exactly fit the need. Cleveland has had 50 years experience in all types of cranes, engineering and building them to meet the customer's requirements precisely.

THE CLEVELAND CRANE & ENGINEERING CO.
1131 EAST 289TH ST., WICKLIFFE, OHIO

CLEVELAND CRANES

MODERN ALL-WELDED STEEL MILL CRANES

Crops *and* Shorts

STEEL industry earnings for 1950 are showing a substantial increase over 1949 figures. United States Steel Corp. reports net income at $215,337,655, about 30 per cent above 1949, while Jones and Laughlin reports a net of $39,744,000 for 1950, more than 70 per cent above 1949. Other companies who have reported to date show, for the most part, increased earnings 30–50 per cent over 1949. Almost every company experienced record sales volume in 1950.

Earnings for 1949 were, of course, penalized by the six-week strike; 1950 earnings benefited from record levels of production, but do not reflect wage and price increases made toward year-end.

Based on sales revenue, however net income in 1950 is only of the order of 7 or 8 per cent—quite low in comparison with other industries.

▲

JUST because progressive education has de-emphasized the old three R's, don't think they are totally gone. Now, at 25, it's Romance; at 35, it's Rent; and at 65, it's Rheumatism.

▲

LAST month this department expressed wonder at the apparent equanimity with which big industry was going along with inflationary processes and granting substantial wage increases even before they were requested. Now that price-wage freeze has come, we can't help but wonder if the moves were calculated to hurry it along. While it is true that freezes do not get at the root of the matter, they will restrain inflation somewhat, and meanwhile, perhaps effective taxation, monetary and credit measures will be set up. And certainly, the freeze will eliminate much of the ground for labor-management disputes.

Incidentally, however, it looks as though a political heat wave is already at work on the freezes.

▲

THE rather drastic roll-back on scrap prices, amounting to some $8 or $10 per ton, will bring about something of a shortage—and probably a lot of conversion deals that may take on a grayish tinge.

▲

A CORRESPONDENT sends us a very simple method for figuring your cost of living. Simply take your total earnings and add 10 per cent.

Another tells us that a necessity is something you cannot get along without, but do, while a luxury is something you ought to get along without, but don't.

And the Wall Street Journal defines "middle class" as those who manage to live in public as the rich do, by living in private as the poor do.

It seems no one can live on what they earn, but everybody does.

▲

IN December this page stated that the steel industry expansion would make obsolete the 110,000,000 ton annual ingot capacity then announced as the goal for the end of 1952, and that unannounced plans pointed toward a capacity of 120,000,000 tons per year by that time. Announcements made since that time indicate an expansion of more than 21,000,000 tons in annual capacity, which will give an annual capacity of 121,000,000 tons of ingots by the end of 1952.

There are still more plans on the drawing boards, and the figure may go even higher.

▲

THE worst thing about the future is that it seems to get here so much quicker than it used to.

▲

SOMEONE has apparently made a discovery—perhaps unwittingly—that should really revolutionize the steel industry. According to a newspaper item, the Ohio State Board of Tax Appeals ruled that blast furnaces that make steel are personal property—not real property. Such furnaces should really make history.

Incidentally, the basis for the ruling, the board said, is because blast furnaces can be moved and are good only for one purpose.

▲

WOMEN should make excellent representatives to Congress. They're so good at introducing bills into the house.

▲

IF this page strays from the field of iron and steel, please blame it on columnitis, a disease that seems to creep up on all who are responsible for regularly filling up nice white paper with ink. Eventually, all columnists start to crusade about something or other, and all become experts on everything, no matter how foreign to their field. Some even try to tell everyone else how to run their business, even when their own is no shining example. Of course we wouldn't do any of these things if we didn't really know what we're talking about.

▲

ASKED to name the books most helpful in his life, one practical mind answered: "Mother's cookbook and father's checkbook."

▲

WE have tried to be charitable about Margaret Truman's singing, but after another hearing, we're inclined to agree with those who wonder how she got out of the church choir. We believe that she is a fine, gracious girl, but we think her father owes an apology to that music critic in Washington.

▲

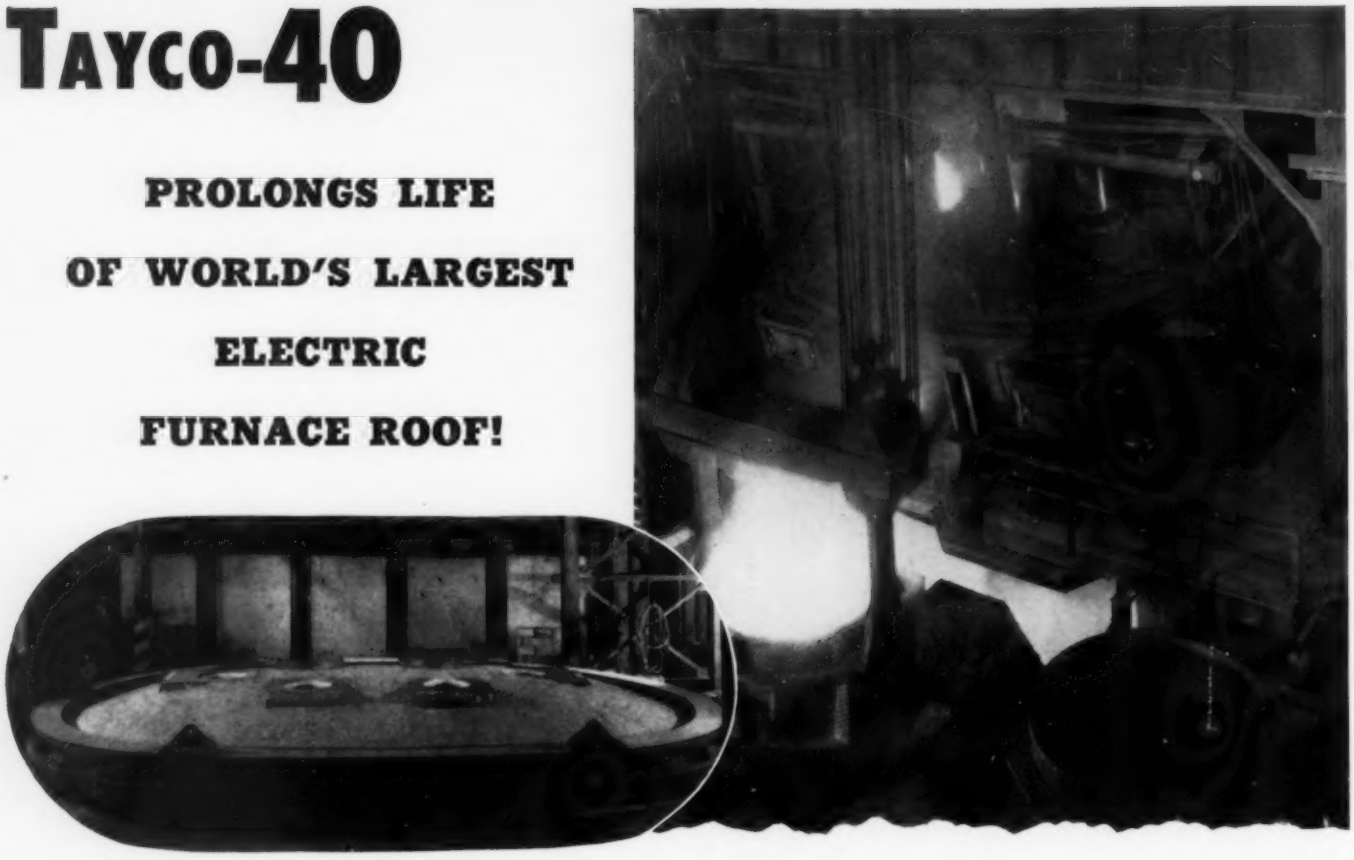
IT'S too bad that so little thought comes out of television in proportion to the thought put into its development.

▲

WORD comes from W. Trinks that up in Fayette county they're serving Truman beer—no head on it.

TAYCO-40

PROLONGS LIFE OF WORLD'S LARGEST ELECTRIC FURNACE ROOF!



100 ton direct arc furnace roof bonded with easy-to-use Tayco-40 Silica Cement. Alloy steel being melted.

The mill which produces alloy steel in the world's largest direct arc electric melting furnace, basic practice, is using Tayco-40 silica cement to prolong roof life. Formerly, silica bricks and shapes were laid dry and then grouted with ordinary silica mortar.

The Melt Shop Superintendent and Masonry Foreman report the following about easy-to-use Tayco-40:

- **The smooth trowelling properties of Tayco-40 make it easier to fit silica bricks or shapes in place with thin, well-filled joints.**
- **Eliminates the necessity of precision cutting on the job.**
- **Prevents silica bricks and shapes from slipping or falling out of the roof when in service.**
- **Tayco-40 will hold spalled or broken ends of brick in place. (Tayco-40 contains no sodium-silicate, is not air-setting and ceramic bond does not begin to form below 1800° F.)**
- **Definite improvement in roof life; roofs withstand rougher handling.**

FOR THE OPEN HEARTH . . . The majority of steel mills in the United States are using Tayco-40 to improve the life of silica open-hearth furnace roofs. Practical experience has proved that roofs bonded with Tayco-40 last longer and can be patched more effectively than those which are laid dry and then grouted with a watery slurry of "silica clay" or mortar.

TAYCO-40 is especially recommended for bonding super-duty silica bricks and shapes, since it is essentially a high silica cement, containing less than 0.50% of alumina. The softening point of Tayco-40 is nearly as high as that of the best grades of silica or super-duty silica brick.

Complete description of properties and other interesting data are given in Bulletin No. 507. We shall be glad to send you as many copies as you need.

Refractorers to industry since 1864.

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8 REASONS WHY SKF IS PREFERRED BY ALL INDUSTRY

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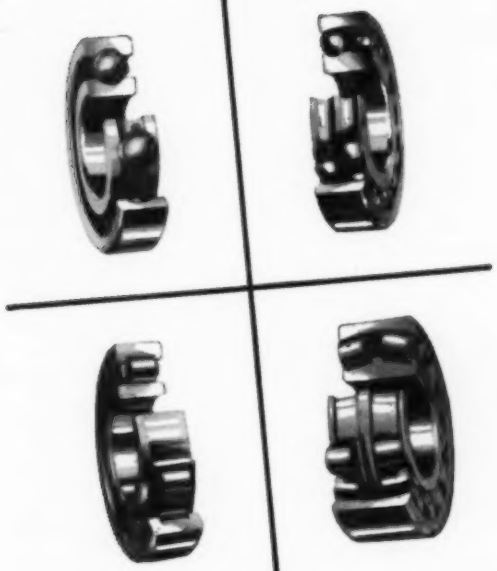
Engineering Service

Surface Finish

make preference for a reason your guide when you specify ball and roller bearings



Over the years, products acquire a value above and beyond their mechanical qualities—a value proved by their *acceptance* throughout industry. This is especially true of SKF ball and roller bearings, preferred by all industry for one or more of eight good reasons. So when you specify, let preference be your guide. 7200

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BALL AND ROLLER BEARINGS

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.
—manufacturers of SKF *and* HESS-BRIGHT *bearings.*

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MOORE RAPID

WHEN YOU MELT... *Lectromelt*

STATISTICAL ANALYSIS OF OPEN HEARTH DATA

. . . . numerous modern statistical tools are available to the open hearth operator to help him in evaluating his operating data . . . .

By WADE R. WEAVER, Director
Steel Conservation and Quality Control
Republic Steel Corp.
Cleveland, Ohio

▲ AS a result of the rather free interchange of ideas among open hearth operators over the past ten years, plus the shifting of personnel, the analysis of open hearth operations has become rather stereotyped. One sees just about the same set of records kept in practically all shops of a given type, and interpretations of these are almost identical. In addition, the evolution of the traditional methods of analysis of such data has resulted in the almost total reliance on averages of data. Much confidence has been placed in the somewhat miscellaneous collection of large masses of figures and the computation of their averages. Things are quite comfortable as long as these averages remain where management "thinks" they should. However, these averages seem to have a habit of not staying put, and when they move into a region which someone "considers" too high or too low, things start to happen. The operator is usually at the mercy of these averages, which never tell him what he is doing, but only what he has done.

Fortunately, there are relatively simple methods available for the analysis of such masses of data and these also provide much additional information for the guidance of decision. Let us examine a few of these and see what modern statistical analyses can do to eliminate "guesstimation," replace "thinking and considering" with specific and factual answers. Let us see how such analyses and interpretations can be simply converted into clear avenues for action.

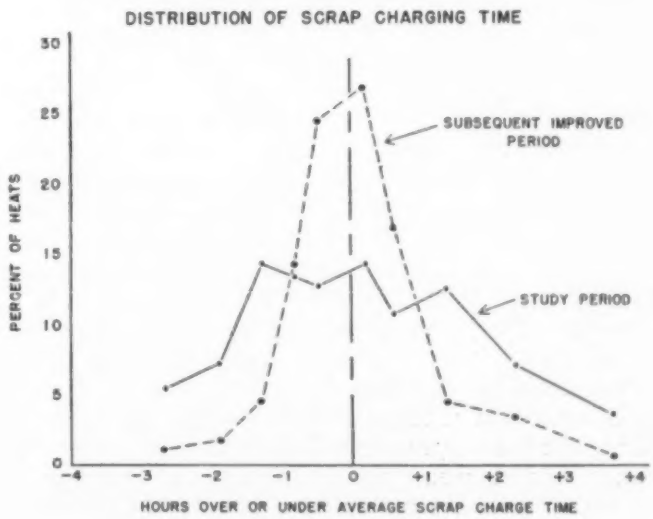
Figure 1 shows one of the simple forms of analysis known as the Frequency Distribution; it shows how often something happened and the magnitude of that occurrence. In this instance, scrap charging times for all furnaces in a given shop in a specific month were grouped in convenient intervals of time. The percentage of the total heats falling in each class interval was calculated and plotted. In this illustration, the intervals are shown as above and below the average time for the month, but could just as readily have been shown as the actual time in minutes. The solid line shows the arrangement of times which existed in the first, or study period. It will be noted that the curve was widespread and flat, had no pronounced peak, and indicated a tremendous variation in scrap charging times. This type of curve is known by analysts to be most unsatisfactory and abnormal.

This scrap charging phase of operations was then vigorously attacked. A subsequent period of one month was similarly calculated and plotted; this is the broken line on Figure 1. It so happens that the average scrap charging time was identical in the two periods yet surely everyone will agree that performance in the subsequent month is to be preferred over that in the study period. The cases at the extreme ends, both very short and very long scrap charging times, have been considerably reduced; there is now a pronounced peak to the curve indicating greater consistency and uniformity of operations. Improvement has been made, yet an examination of merely the average of the times in the subsequent period would indicate efforts toward improvement had been to no avail.

Practically any of the day-to-day data resulting from open hearth operations can be so treated and converted into a picture of this type. It is a simple operation, not complicated or time consuming, and can be readily performed by any clerk. "But," it will be said "that is still only history; it tells what has happened and not what is happening." This is true, but an equally simple technique known as the Control Chart to be discussed below will present a picture of the day to day progress.

Figure 2 shows a frequency distribution of the sizes of heats tapped from furnaces of identical size and making the same grades of steel, for a period of one month. The average heat size (201.3 tons) might be "considered" satisfactory as based on past history, but a quick look at the curve tells quite a different story. The

Figure 1 — Chart shows distribution of scrap charging time. The dotted line indicates a much better charging procedure even though the average may be the same as that of the solid line.



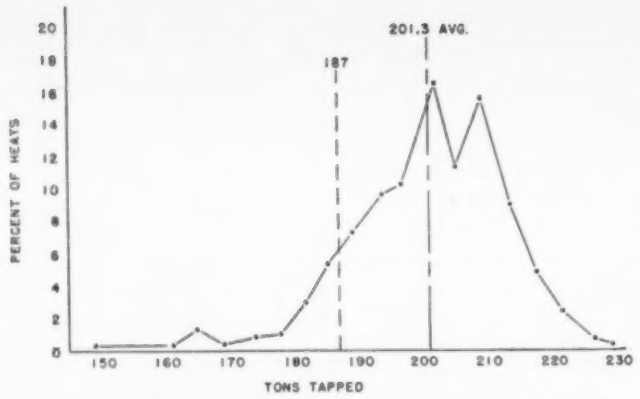


Figure 2 — The chart shows the distribution in the sizes of the heat for a one month period.

spread is from 150 to 230 tons; the curve slopes steeply down in the high tonnage range where there are practical limitations to heat size, but it tails off gradually into the low tonnage range. This latter is a reflection of the attitude that "an occasional small heat is to be expected and does not hurt much." How frequently these "occasional small heats" are occurring and "how small" a heat should be expected to be is the crux of this problem.

In this case there were 41 heats below 187 tons in size, a figure which the correct analysis of these data indicates to be the smallest heat which should normally be expected, and if these 41 heats had been of only average size the shop would have produced 900 tons of additional steel during the month.

This improved condition could not have been achieved merely by efforts to increase the average heat size. Heats which are too large are more undesirable than heats which are too small. The emphasis must be on controlling variation in heat size and in attaining this the aim should be to eliminate the small heats and work toward the highest possible percentage of "standard" size heats. It is important that supervision have some criterion to judge what is "too small" or "too large" in order to have a picture of progress and it is here that the value of the Control Chart is evidenced.

The same data have been arranged in control chart form in Figure 3. The upper portion of this chart shows the average size of five consecutive heats as each point continues chronologically from day to day. The lower portion shows the range, or variation from largest to smallest within the corresponding group of five heats. The center lines (solid) represent average conditions from the previous period (judged satisfactory) and the broken lines are upper and lower "expectancy" limits. As long as conditions continue to run along as they formerly did, no average of five heats should be expected to go either above the upper line nor below the lower line for averages, nor should an individual range point be expected to fall above the range limit. If this does occur, or if a concentration of points appears close to these limit lines, something has changed and conditions should be investigated at once.

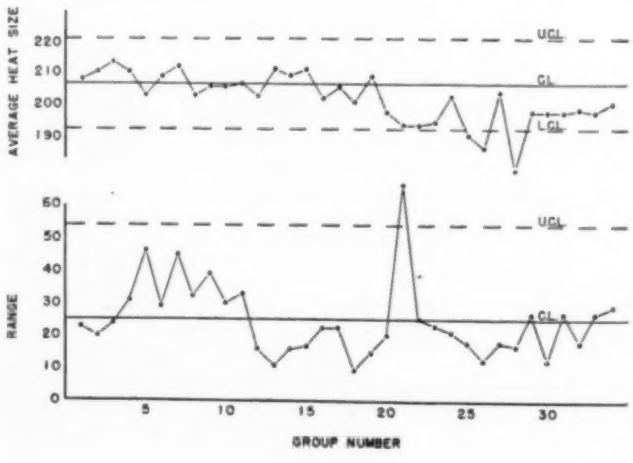
Examination of Figure 3 will show that things went along about as expected until the 21st group. Here the range suddenly went "out of control" indicating greatly increased variation in size from one heat to the next. Note, also, the concentration of "averages" near the lower limit line and that they finally went "out of control" on the low side. These low points are the cause for the long tail on the low side of the frequency distribution in Figure 2. If the control chart had been maintained daily during the production, and if supervision had taken action when action was indicated. (about the 20th group) these abnormally small heats could have been eliminated and the average heat size for the month increased 2.8 tons. Thus, the importance of variability rather than average as a determining factor in results, is clearly shown.

This control chart is likewise simple to construct, requires no specialized training and can be performed by anyone with a knowledge of eighth grade arithmetic. It is really a refinement of the familiar and over-used "running record" chart. In this latter type of chart, individual readings are plotted rather than averages and ranges of small sub-groups as is done in the control chart. As a result, much important information is too frequently hidden.

A specific grade of steel, produced in rather considerable tonnages in a given shop, developed surface troubles in the billet stage. All the "well-known" causes were examined with no apparent success while the poor surface was becoming worse. Figure 4 shows the characteristic running record chart on pouring temperature, a factor of recognized importance. Very little worth-while information can be, or indeed was, deduced from this chart. This same set of data, however, when treated in control chart manner as in Figure 5 and compared to prior history when the surface was relatively good, (the average and expectancy lines) immediately brought out the facts. The variation in pouring temperature from heat to heat masked the slowly increasing trend, and had the control chart method of analysis been in effect action could have been taken in time to prevent the bad surface which resulted when the pouring temperature finally exceeded tolerable levels. Just incidentally, a downward modification of pouring temperatures actually cleaned up the trouble.

From day to day, week to week, month to month, as time goes on, averages of open hearth operating data

Figure 3 — The control chart which shows sizes of five consecutive heats shows more clearly when something unusual happens.



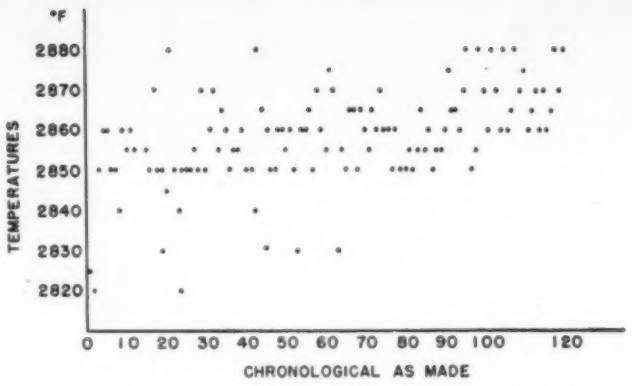


Figure 4 — The pouring temperature of individual heats is given by this chart.

vary considerably. Some of this variation is due to random causes; some of it may be due to a gradual, but unintentional and unnoticed change in individual performance; some of it may be due to intentional efforts to alter a given situation. The amount that an average may vary due to chance causes alone is sometimes surprising and it is therefore advisable to have an accurate appraisal of such chance variation in order to avoid erroneous, and frequently embarrassing conclusions. A tool to evaluate these changing conditions is available and is called significance of differences. It provides the means for indicating just what part chance has played in the changing level and with what degree of confidence the difference can be attributed to specific causes. These tests are quite adaptable to a large variety of situations, but require a little specialized training to execute, being somewhat more complicated than the frequency distribution or control chart techniques.

Table I is a tabulation of the analysis of scrap charging times in four weekly periods. In the first, or study period, a frequency distribution of times was made which indicated the average was high and the variability great. A campaign was instituted to "reduce scrap charging time" and the average for the second week was 17 minutes lower. Everyone was satisfied that their efforts had been rewarded, though the improvement was small, and the campaign was extended. In the third week the gain of 17 minutes in the second week was lost, plus an additional 8 minutes, for a total loss in the third week over the first of 25 minutes. How could this be?

TABLE I

PERIOD	OBSERVED DIFFERENCE ABOVE OR BELOW 1ST PERIOD	ONLY-TO-BE-EXPECTED DIFFERENCE	ODDS THAT DIFFERENCE DUE TO CHANCE ONLY
1	—	—	—
2	−17 MINUTES	13.2 MINUTES	1 IN 5
3	+8 MINUTES	12.6 MINUTES	2 IN 3
4	−47 MINUTES	12.7 MINUTES	< 1 IN 100

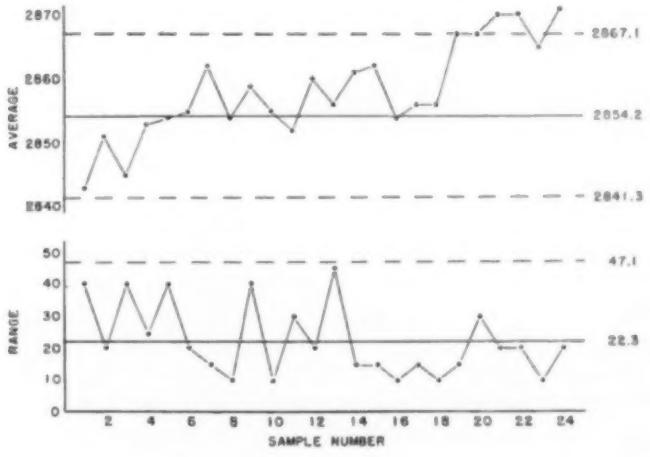
The significance of difference between periods of scrap charging times is illustrated in this table.

Analysis of the data by different techniques showed that if, in the second week, scrap had continued to be charged identically as in the first week, a difference of 13.2 minutes in the average, either up or down, could be expected merely due to chance variations in individual heat charging times. Further, it is a 1 in 5 chance that the observed difference of 17 minutes improvement was due to random variation. Since, in order to be significant, this chance would have to be at least 1 in 20, it was decided that the method of attack in the second week had possibly resulted in no real improvement. This was borne out when similar methods used during the third week resulted in an even higher figure than in the first week. Analysis here shows that a difference, up or down, of 12.6 minutes in charging time could have been expected due to purely random, chance causes and further, that it is a 2 in 3 chance that the change in average was merely fortuitous.

Accordingly, a new method of attack was selected for the fourth week and an improvement over the study period of 47 minutes in the average resulted. Calculation now shows that the chances are 99 in 100 that the improvement was not due to chance but to the action taken. A further test was applied and frequency distribution of times in the fourth week plotted. Although the average time was reduced, the significant change was in variation of scrap charging times from heat to heat. The next logical step would be to set up a control chart to show the day to day progress and level so that immediate action may be taken to keep things "in the groove." No doubt supervision did have something to do with the improved figure in the second week, but the variability of the system was so great that no permanent improvement could be attained until this was substantially reduced.

Another very common problem in analyzing open hearth data is the study of relationships. Operators are constantly faced with determining the relationship between fuel rate and furnace life, per cent of hot metal in the charge and tons per hour, per cent of limestone charged and heat time or final sulphur, and a hundred or a thousand other such relationships. The conventional method has been to plot values representing the characteristics to be studied on graph paper and draw,

Figure 5 — This chart shows the trend of pouring temperatures much better than that given in Figure 4.



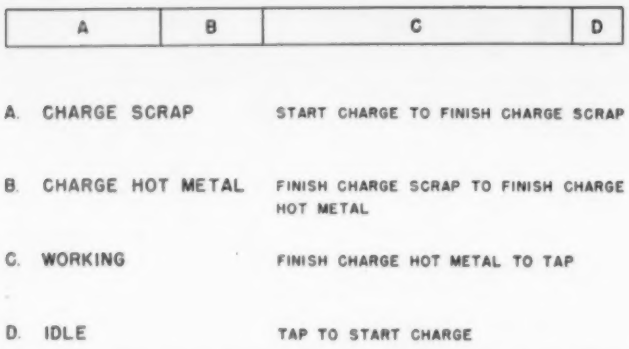


Figure 6 — Bar chart shows one division of total heat time.

by inspection, the line which seems to represent the best relationship. A more advanced method is to determine these lines by mathematical calculation, a technique known as correlation. Sometimes these are straight lines, sometimes curved.

It is a well recognized, but not sufficiently well appreciated or understood fact, that the study of such a simple relationship is, in reality, not simple at all. There are many other variables affecting final sulphur other than the limestone charged; many things may, and probably do, have a much more pronounced effect on furnace life than fuel rate. For this reason it is all too frequently quite misleading to draw conclusions from the apparent relationship existing between fuel rate and furnace life and ignore all the other variables that are known to exert a pronounced effect and which were undoubtedly exerting their respective effects to varying degrees concurrent with the variations of fuel rate, the item under study.

Is there a way by which we can include the varying effects of several of these variables, or perhaps all of the recognized ones, and then sort out the individual and independent effect of each one by itself, excluding the effects of all the others? Yes, there is such a tool and it is known as multiple correlation. As a simple example, if we should study the relationship existing between tons per hour and (1) scrap charging time, (2) pounds of limestone charged, (3) per cent of hot metal charged, (4) sulphur in the hot metal and (5) fuel rate, the results obtained by this multiple correlation analysis would show the specific effect of any one of the 5 variables on tons per hour, independent of the effect of any of the other four.

This is quite an involved and complicated technique, impossible of execution without some highly specialized training. Until recently it was also extremely laborious, but certain technological advances in methods and equipment have shortened it materially. There are two definite phases involved; first, the mathematical computation and second, the useful interpretation. The first has been available for years, but the second has been noticeably lacking. Obviously, any mathematical result must be interpreted so that it can be intelligently used by operators. The mathematician has a woeful lack of practical open hearth operating experience, and the mathematical procedures have not been readily available to the operators.

Let us examine the potentialities of this tool to assist in solving a problem of universal interest to all open hearth operators and one which practically defies solution except by the use of this specialized technique.

Everyone is interested in reducing total heat time. The correct approach to this is a study of the variability of heat times. If we knew what combination of events resulted in short heat times, what caused long heat times, and if we could eliminate or materially reduce the number of long ones, life in an open hearth shop would be a much happier one. Suppose we examine this variability situation a little.

Figure 6 shows one rather common and logical way of dividing up the total heat time, charge to charge. Variations in period A will depend on many factors such as furnace size, amount of scrap charged, physical nature of scrap, charging box sizes, type of fuel and rate of firing, transportation and other charging facilities, number of furnaces charging at one time, etc. Period B will vary according to the amount of hot metal being charged and availability of same, ladle size, condition of furnace and charge at time of adding, etc. It would take a long time to enumerate the known, or suspected causes of variation in Period C and similarly for Period D. Every operator has his own ideas about these various factors; there is reasonable agreement on some, but violent disagreement on others. What are the facts? Again, the correct approach is a study of the various factors responsible for variations in elapsed time of these individual periods, or similar periods, and the relationships existing between those factors affecting an individual period, as well as the relationships between the periods themselves and the effects of these relationships on total heat time.

Data were collected for a period of time, by individual furnace, and analyzed. A study of the relationship of the periods A, B, C and D to total heat time was made to determine the ranking order of importance that their respective variations had on the variation in total heat time. This data is tabulated in Table II.

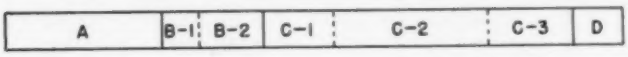
TABLE II

EFFECT ON VARIATION	FURNACE NUMBER						
	1	2	3	4	5	6	7
MOST IMPORTANT	C	D	A	A	B	A	C
NEXT MOST IMPORTANT	A	A	C	C	A	B	B
THIRD MOST IMPORTANT	B	C	B	D	C	D	A
LEAST IMPORTANT	D	B	D	B	D	C	D

The relative importance of four periods in total heat time.

It will be observed that the same period is not of primary importance on all furnaces and that a specific period changes its position of importance from one furnace to another.

A "conventional" analysis was made on one furnace, showing merely the apparent relationship between each period, separately, and the total. This indicated the scrap charging period to be the major offender, yet when analyzed by the multiple correlation method the



B-1 FINISH CHARGE SCRAP TO START ADD HOT METAL

B-2 START ADD HOT METAL TO FINISH ADD HOT METAL

C-1 FINISH ADD HOT METAL TO START LIME BOIL

C-2 START LIME BOIL TO FINISH LIME BOIL

C-3 FINISH LIME BOIL TO TAP

Figure 7 — It may be desirable to break down heat time into more refined sub-divisions.

effects of various combinations which existed were eliminated and it was found that actually the idle period was greatest in importance.

A little study of operating conditions along the foregoing lines will quickly develop some interesting, and perhaps hitherto unsuspected facts. A probable logical conclusion will be that some further refinement in division of total heat time is indicated. For example, as in Figure 7, the original period B might be divided into B-1 and B-2; period C might be further sub-divided into C-1, C-2 and C-3, etc. As things become more and more complicated the absolute necessity for some mathematical process to keep our thinking straight becomes apparent.

The result of such studies will undoubtedly evolve optimum working ranges for the various periods. It may develop, for example, that it is undesirable to reduce a specific period to too low a point, because of the adverse effect this would have on some following period, thus resulting in an overall increase in heat time, a net loss. This is a virtually untouched field and offers promise of very lucrative returns.

To sum up, there are numerous modern statistical tools available to open hearth operators to aid them in a more rapid and factual evaluation of operating data. Some of these are extremely simple and easy of execution; others are moderately involved, and some are highly technical and laborious. Immediate use could be made of the simple ones by any open hearth operator. These would lead to an appreciation of the somewhat technical ones and a realization of their value to progress. The universal results, if properly handled, will be the substitution of fact for opinion, the establishment of definite bench marks, an improved and sharper knowledge of what a process or part thereof can be expected to do, the high-lighting of the most important factors, and the spot-lighting of the trouble spots, thus enabling supervision to make the best possible use of their time and effort, the cracking of the tough problems and finally, and most important of all, an easier and happier lot for melt shop supervision.

DISCUSSION

PRESENTED BY

P. E. HAGLUND, Superintendent, Raw Materials and Semi-finished, Ford Motor Co., Dearborn, Mich.

M. J. GEIGEL, Practice Engineer, Youngstown Sheet & Tube Co., Youngstown, Ohio.

HARRY W. CLARK and R. GUTHRIE, Ford Motor Co., Steel Operations, Dearborn, Mich.

RALPH H. GELDER, Works Metallurgist, Armco Steel Corp., Ashland, Ky.

P. E. Haglund: The frequency curve in Figure 1 brings out a pertinent story that cannot be disregarded. Hard and fast figures to prove the point are difficult to produce, but with a little imagination, it is a good picture of a bad and a good condition.

Disregarding the extremes on either side of the average, a better picture to my mind is evident. You will always have conditions in an open hearth creating extremely short and especially long charging times due to accidents, break-downs, and other problems attributed to the human element. To make the picture more clear, draw lines representing 1½ hours below and 1½ hours above the average. During the first month of the study period, roughly 64 per cent comes within that range. After corrections have been attempted, 91 per cent comes within those lines. The facts are evident that more uniformity in charging time has been established and nothing I can think of will lead to a more satisfactory lime-up-carbon.

An ideal lime-up-carbon is very important to both increased production and improved quality. Let us analyze this statement. I do not believe many would disagree with me, but that the tapping weight would be improved in uniformity. The charge to tap time would be improved, and consequently, the scouring of the bottom and banks would be on the decrease. There is a relationship between the time of the heat and the tapping temperature. This would be decidedly improved. Also, an improvement in quality could be expected. Questionable quality is very often the result of either too high or too low a lime-up-carbon.

It is safe to say that anything that will lead to a uniform charge to tap time will be a decided improvement in open hearth operations. Just imagine tapping heats in 11 or 12 hours with greater consistency to compare with a condition that will produce one heat in 8 hours and the next in 16 hours.

The picture the frequency curve portrays is not complete, however. It does not give you tons per hour per furnace. No allowance is made of the speed of each individual furnace. The physical make-up of the scrap piles from month to month is overlooked. Good or bad layouts of the charging floor does not get any attention. All the above variables and many others are arguments against this frequency curve, but it does set up a new line of thinking from averages to frequencies of occurrence, and that, I sincerely hope and believe, will have a tendency to improve both quantity and quality of our open hearth steels. The importance of variability (instead of averages) cannot help but get more attention in the future.

Mark J. Geigel: I wish to point out that, in every open hearth, this method of calculation is being used very extensively. Of course, I can only speak for our company but I am sure other companies operate under similar techniques. The most extensive user of distribution curves is the melter. He does not actually have a chart plotted, but when he makes his additions of manganese and carbon, a distribution curve appears in his mind. He does not take an average of heats that he has made in the past, but he considers all the conditions, such as large heat vs small heat, high oxidation vs low oxidation, tapping conditions, margin of error in sampling, etc. These high and low figures are his upper and lower control limits. He then tries to make his additions to meet the center of these limits to hit the specification.

As Mr. Weaver has pointed out, it is very helpful to the open hearth superintendent to keep the size of heats uniform. The use of control charts alone for known variables is not always enough to give a complete picture for cause and effect. For this reason, at our plant, the superintendent is given certain low and high figures which he uses for a yardstick, these figures having been determined by distribution curves, multiple correlations, and the like. In the case of heat size, we have limits of 150-170. As the superintendent looks over his 24-hour report, he, too, has a control chart in his mind, knowing that too many heats below 155 means lost tonnage and too many heats around 170 means lost tonnage through thimble chunks.

Another application of distribution curves was very helpful at the Campbell open hearth. We are fortunate in getting about 20-25 heats out of a steel ladle lining. By careful observation and the use of distribution curves, we are able to take advantage of the wearing of the lining. We increase the size of the heat charged according to the number of heats on the lining. The use of average heat size would have never given us this bonus tonnage, whereas distribution curves made it very apparent.

In conclusion, I believe that the use of statistics, distribution curves, control charts and multiple correlations are very useful tools with which to set up practices in the open hearth. However, the open hearth operator must exercise extreme caution in the use of this tool. There are about 20 known variables that affect one item, production. Since these variables are all interrelated, a thorough knowledge of the problem from the standpoint of metallurgy, costs, etc., is necessary to get workable results. The wise operator sets up his standards with statistics, and then knowing the limits with which he wants to work, spends his time in the shop to see that the job is being done. It is often quite hard to tell whether theory, mathematics, or horse sense is the proper tool to use.

Harry S. Clark, and R. Guthrie: Mr. Weaver's paper offers a method of attack on open hearth problems that have long been recognized. We have been working on improving our scrap-charging time continuously, and have managed to develop a certain amount of control over the segregation of scrap as was reported in R. Fiens "Scrap Preparation," Iron and Steel Engineer, Nov. 1949, p. 96.

We are using the frequency curve in our open hearth as a means of alerting supervision to the variations in scrap charging time that is encountered, and find it highlights the condition very well.

Statistical methods and graphical presentation of results are being applied in our quality control program as a means of highlighting variables that cause trouble in subsequent operations. This is accomplished by Bar-X charts on a turn basis and a monthly trend chart. These charts are located at the operation, and show the operators their score each day as compared to the other turns. These are proving to be a definite aid to supervision in two ways:

1. Alerting them to the trend of conditions existing in their operation.
2. Showing the men what is required and arousing their interest and pride in a job well done.

Ralph H. Gelder: The subject of statistics is like that of safety, it concerns all of us whether we are metallurgists, open hearth operators, mill operators, safety advisors, etc. The list of those concerned with statistics would read like a list of all management and supervisory personnel in your plant.

There are three principal steps which must be taken in any statistical procedure in order to obtain the maximum amount of contained information. They are: (1) the collection of the data, (2) the analysis of the data collected, and (3) the interpretation of the results. All of us are familiar with and use the first step in this procedure which is the collection of the data. The next two steps are those in which practices vary widely and are the ones with which Mr. Weaver is most concerned in his discussion. Too often the full amount of information contained in a set of data is never uncovered because sound statistical methods were not used in analyzing it.

I am in hearty accord with Mr. Weaver's excellent presentation and can add little to it except to say that we use it every day. In metallurgical work, it is frequently necessary to deal with voluminous amounts of data from which it would be almost impossible to obtain any result at all without the use of statistics. Every problem which is presented to us, and which is reducible to numerical values, is analyzed statistically. This statistical analysis sometimes may be no more than a simple numerical average, but sometimes it may involve a complicated multiple correlation study. Therefore, it is vital to us to always have available people who are capable of dealing with statistical methods.

The best statistical analysis possible is of no practical value unless use can be made of the results obtained. This brings into the front of the picture the position of the operating man, because he is the one who must put the results into actual practice. It has been our experience that most operating men have been very receptive to statistical methods if they have been given concrete evidence of the benefits obtained by them.

Mr. Weaver has chosen some excellent examples to indicate the value of statistics over that of simple observation of the data; however, it is difficult to realize how much valuable information has been lost until a statistical program has been inaugurated in your plant.

MODERN BLOOMING MILL PRACTICES

By D. W. LLOYD
General Superintendent
Youngstown Sheet & Tube Co.
Youngstown, Ohio

. . . . to reduce surface defects requires close cooperation and study by all departments in the steel plant . . .

▲ IN the past decade a great improvement has been made in rolling mill design and layout. Material on this subject is available in trade magazines, technical papers and texts. It is therefore the object of this paper to discuss a problem which still continues to confront rolling mill operators. It is the problem of determining the source of surface defects and their control. These sources have been divided into four groups: (1) open hearth, (2) soaking pits, (3) rolling mill, and (4) conditioning yard. It is quite often impossible to determine the cause of defects from a postmortem examination of the semi-finished product, as defects from different causes may appear identical. If such a defect occurs continually, it is necessary to set up experimental procedure and obtain samples in the various stages of operation. From these samples the initial formation of the defect can be observed and possible corrective measures indicated.

The effect of open hearth deoxidation practice and pouring pit practice will be discussed in connection with the formation of surface defects and sub-surface defects.

Poor practices in soaking pits and reheat furnaces, such as overheating, underheating, uneven ingot temperatures and the effect such practices have on the product will be discussed.

The rolling mill is responsible for defects of a mechanical nature, such as overfills, underfills, laps, scratches, shearing, etc., which necessitate conditioning in the semi-finished product.

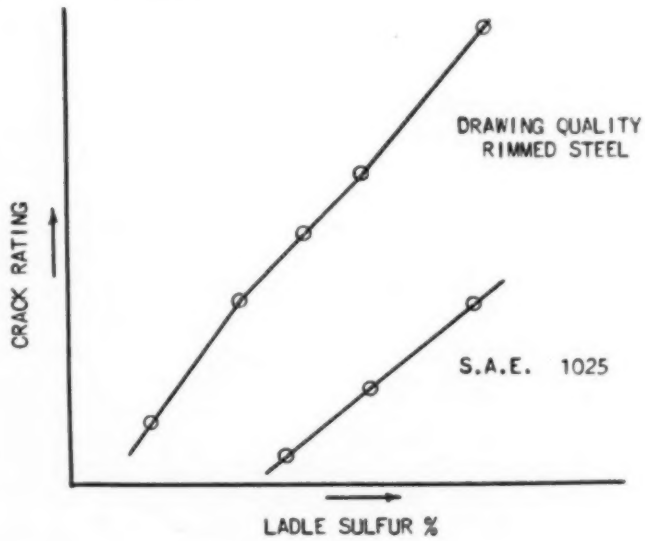
The conditioning yard must remove the above mentioned defects that are present in the bloom or slab and at the same time produce a surface which will process satisfactorily in the subsequent rolling or forming.

In view of the many sources of defects, it can be readily seen that their control is a problem of major importance. Probably the most difficult to control are those which originate in the open hearth.

No discussion of surface quality in semi-finished steel can be presented without first considering defects or weaknesses inherited from the open hearth by the rolling mill. Outstanding in this respect is the effect of sulphur on surface cracks. Figure 1 is a correlation between sulphur content in two grades of steel and the relative amount of cracking that occurred in the blooming mill rolls. This data merely reviews again the characteristic effect of sulphur on hot shortness.

M. Tenenbaum[1]* has indicated that: "Sulphur forms sulphides with both iron and manganese. In steels with a low manganese to sulphur ratio, considerable free iron sulphide appears in a brittle inclusion network or film distributed throughout the grain boundaries. The melting point of iron sulphide is relatively low (2170 F). The sulphides of iron and manganese are mutually soluble, and form eutectic mixtures with their oxides. When the ratio of manganese to sulphur exceeds 7 to 1, the characteristic pattern of free iron sulphide can no longer be detected under the microscope. Instead, a higher melting double sulphide with manganese

Figure 1 — Curve illustrates how increasing sulphur increases crack rating.



* Numerals refer to Bibliography at end of article.

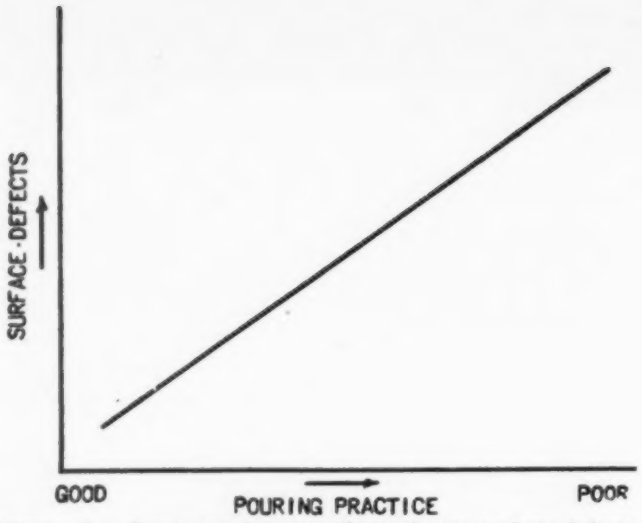


Figure 2 — Good pouring practice reduces surface defects markedly.

forms. This latter sulphide appears in globular form rather than in an intergranular network.

"It has been postulated that on reheating hot short steels to working temperatures, the iron sulphide film or network disintegrates or fuses in the grain boundaries. The application of the hot working force then results in the hot short cracks."

With the sulphur problem becoming increasingly important, as a result of higher sulphur raw materials, the necessity for good soaking pit practice becomes apparent.

Poor teeming conditions contribute greatly to surface defects which may or may not be removed by conditioning. Opinions have been expressed that defects resulting from a tilted nozzle are never completely removed. Heavy scabs on the mold walls formed as a result of running stoppers, canted nozzles, or umbrella shaped pouring streams, not only form a laminated structure on the surface of the steel, but also form blow holes under the surface of the ingot, as a result of the reaction between the oxidized surface of the scab and the carbon in the molten steel as it rises over the scab. This same reaction occurs with good nozzle conditions, if molds are not well covered with suitable mold coating, and the small splashes that are always present adhere to the mold wells instead of dropping back into the ingot body.

Mold scabs tend to occur, particularly on the butt of the ingot, as a result of the initial splash when the pouring stream hits the base of the mold or stool. Some success has been reported in the use of larger size nozzles, which by increasing the rate of rise, tend to reduce the oxidizing time of these splashes. The effect of pouring pit practices on finished product is shown in Figure 2. Outside defects increase considerably as pit practice becomes worse.

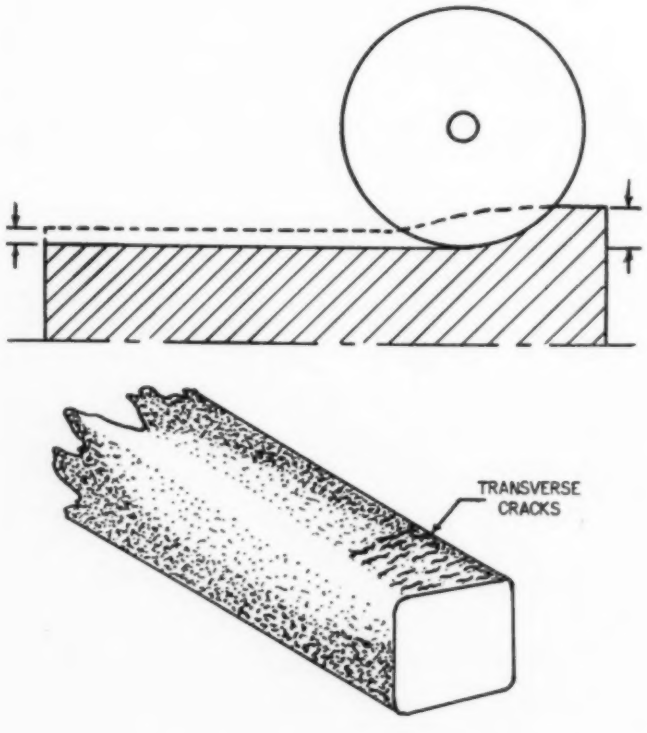
The two sketches of Figure 3 show an ingot obtained from a heavy gouged mold and the resulting defect in the bloom. In rolling this type of ingot, normal draft becomes excessive, as the butt of the ingot approaches the rolls. As this section is reduced, the outside fibers of the ingot are ruptured, leaving many transverse cracks on the butt of the bloom.

Regarding inclusions[2]: "Non-metallic inclusions that occur in steel may be in the form of furnace slag, deoxodizing slag, refractory particles and their reaction products. Furnace slags entrapped in the bath, due to various reasons, usually have time to rise to the surface of the ladle if they are in the form of relatively large particles. However, since furnace slags as a rule are finely emulsified, they constitute a problem of purity, not only to the surface of the steel, but also to the body of the steel itself."

Slag particles which are products of deoxidation procedure also result in similar defects. The control of non-metallics which result from deoxidation is one of the major problems in any steel plant. Their formation is primarily a function of the degree of oxidation of the heat. Their type, size, position in the ingot and occurrence in the finished product are not only a result of deoxidation practice, but also of heat temperature and pouring pit practices.

The non-metallic inclusions that may be attributed to refractory particles and their reaction products are brought about by different conditions. The ladle brick, nozzle brick and especially the runner brick are not always able to withstand the fluctuating temperature or erroding action of the stream. They often crack, crumble and become entrapped in the molten steel. These refractory particles and their reaction products are found anywhere in the ingot, since they rarely have the opportunity to rise to the top of the mold. A few precautions against any such ingot defects may be listed as follows: sound bricks, a teeming ladle which is not so high that it will entail excessive ferrostatic pressure on the nozzle, dry storage of the bricks for runners, proper fit of the runner bricks, etc. The practice of using a loam slurry for coating runners can also

Figure 3 — Top sketch shows effect of deeply gouged mold on draft, and the bottom sketch shows the resultant transverse crack in the bloom.



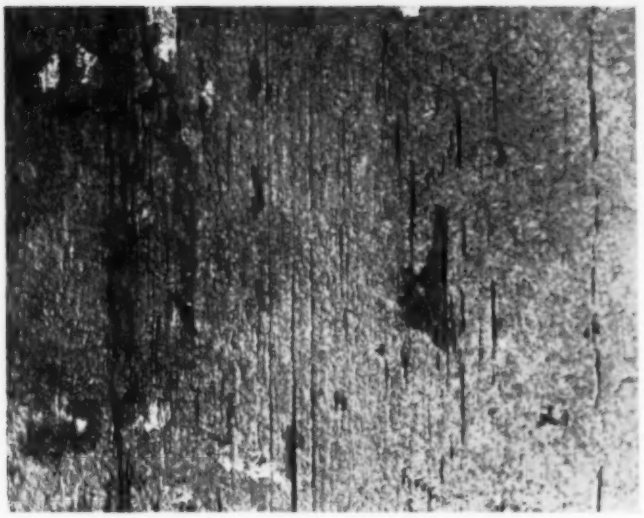


Figure 4 — Illustration shows typical hair seams in a semi-finished round.

be a source of silicate inclusions, if the loam is high in sand content.

The non-metallics and blow holes which occur just below the ingot skin may be bared if the ingot is washed in the soaking pit, or they may appear after scarfing or chipping in the conditioning yard. In subsequent rolling, they form hair seams which are elongated in the direction of rolling and occur irregularly at varying depths. Figure 4 is a picture of typical hair seams. The inclusions can sometimes be identified under microscopic examination by characteristic colors or by petrographic examination. Identification will then indicate corrective or experimental measures.

Gruner and Bruggemann[3] have stated that a banded structure may develop if the dendrites and the more spherical crystals do not have a uniform composition, and if the structure is elongated by reductions in rolling. A non-uniform composition of the dendrites and the globules is produced by microsegregation during the primary crystallization. Moreover, structural inhomogeneity may be caused by normal and inverse ingot segregaton and also blow hole segregation. The bands produced by blow hole segregate are distributed less regularly over the cross-section of the piece than are the bands produced by microsegregation. The most harmful source of banding is the occurrence of plastic non-metallic inclusions, such as silicate. Since these inclusions become centers of crystallization, they not only affect the primary structure, but also the secondary structure. There is always found a marked precipitation of ferrite at the elongated inclusions. Banding does not entail an appreciable deterioration of the physical properties in the direction of the fiber, however, the transverse properties suffer appreciably.

The most pronounced segregation in steel is caused by sulphur, phosphorus and carbon. Zones enriched by these elements can be found especially near blow holes. Sulphur and phosphorus segregations or banding cannot be eliminated, even by prolonged normalizing. However, with sufficiently high temperatures and sufficiently long heating times, the carbon content, because of its high degree of diffusivity, will show a distribution more uniform than that of sulphur or phosphorus. According to H. Cramer[4]: "A blow hole must be regarded as the cause of a crack occurring in a rolled product, if upon etching, there is revealed an enrichment of the crack with phosphorus." The rolled steel, in many cases, may show a smooth and sound surface after rolling, however, surface defects may develop after pickling. Only after pickling can such cracks be clearly recognized, because they start from the surface as vein-like inclusions, which do not become visible until they have been attacked by pickling solution. Since a pickle test always consumes time and only short pieces of any one mill length can be so tested, it is possible to roll a large quantity of defective stock before a defect can be discovered. For this reason the upset test is sometimes used, since it can be made continually during the rolling operation, and only requires a few seconds to perform. With this test, most of the steelmaking and also the rolling defects can be discovered, since the test piece can be subsequently pickled.

Another defect which is quite common and relatively easy to remedy is the hanger crack. This type failure occurs with refractory lined metal hot tops when the hot top is held up by blocking or is wedged in the mold top. As the ingot shrinks away from the mold walls and hangs suspended by the hot top, the outer fibers of the ingot are overstressed by the weight of the ingot and develop cracks just below the hot top. See Figure 5. The prompt removal of blocking and sufficient clearance between tops and molds will usually correct this condition.

The control of blow holes in rimmed, semi-killed and capped steel is one of the major problems in all plants producing these types of steel. The depth of these blow holes is a function of the deoxidation practice. In semi-killed and capped steel, the amount of deoxidation required is held in fine balance, since under-deoxidation will place the blow holes too near the surface and over-deoxidation will produce piping. In rimmed steels, a sound skin is obtained through good vigorous rimming, and a dropping action in the mold. The importance of the depth of skin will be discussed in connection with soaking pit practice.

The greatest hazards in heating are burning the ingot and the formation of sponge. In the finished stage, both types of defects look very similar as shown by

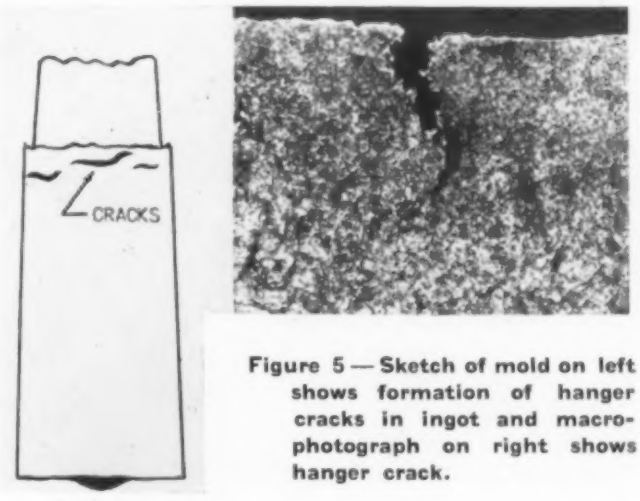


Figure 5 — Sketch of mold on left shows formation of hanger cracks in ingot and macrophotograph on right shows hanger crack.

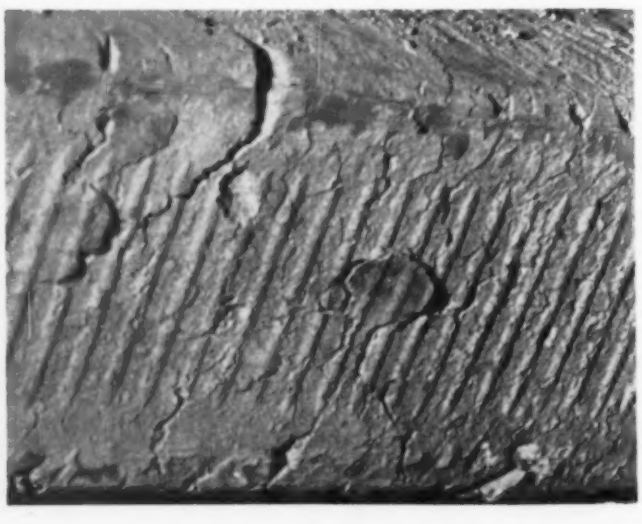
Figure 6 — Illustration shows rolled steel which has been burnt in the soaking pit.

Figure 6, which is a burned bloom of dead killed steel and Figure 7 which is spongy rimmed steel. However, there is a difference in the mechanics of their formation which may be traced back to the open hearth, blooming mill soaking pits, or both. Burned steel is due to a hot flame concentration which melts out from the ingot, the lower melting segregates. A spongy ingot is created by washing away the surface of the metal and opening to oxidizing atmospheres the sub-surface blow holes. These oxidized surfaces will not weld together during rolling. In either case, the results are increased scrap losses, increased conditioning costs, or both.

It might be well to mention that increased heating times will cause excessive scaling which will also open sub-surface blow holes to oxidizing atmospheres. In some steels, particularly resulphurized grades, excessive heating time will also cause severe cracking of the ingot during rolling.

From time to time in blooming mill operations, an ingot is rolled cold, that is, before it has reached a temperature sufficiently high for rolling without excessive surface cracks. Slabs or blooms which have been rolled cold will show transverse cracks, as a result of overstressing the outer fibers of the ingot.

Figure 7 — Illustration shows rimmed steel having a spongy condition.



Uneven heating can also be a cause of defects in the rolling mill. As a result of temperature differentials in opposite sides of an ingot, the elongation on opposite sides will vary sufficiently to form a "rocker" with the colder side being innermost. Cracks will develop primarily on the corners of the cold side as succeeding passes straighten out the "rocker."

Steels which are sensitive to thermal shock must be handled with extreme caution in the soaking pits. It is essential that pits be cooled down to the approximate temperature of the ingots being charged and then allowed to set with pit dampers down until the ingot, inside and out, has reached a temperature equilibrium with the pit. A slow and uniform rise to rolling temperature is also necessary. Without these precautions, cracks will develop on the ingot before rolling and the oxidized surfaces of the cracks will not weld.

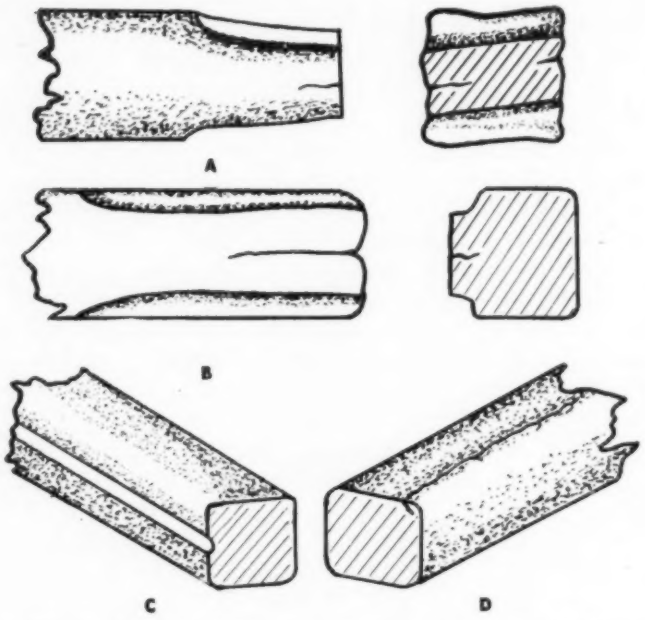


Figure 8 — Sketch A shows rolling mill turn down; B shows collar marks; C shows guide mark, and D shows mill lap.

Reheating furnaces can, in general, cause the same defects as the soaking pits. Burning, uneven heating, insufficient heating, thermal shock will have the same results.

Four different types of defects are illustrated by the sketches of Figure 8. The first of these, Figure 8A is a turn-down which is formed when an ingot or section twists in a pass. This is the result of: (1) faulty mill alinement, or (2) pass design, (3) size of section, or (4) improper draft. With careful control of these factors, little trouble should be encountered with this defect.

Collar marks, Figure 8B, are caused by any one of several poor practices, which may be enumerated as follows: (1) improper heating, which causes the section to spread too much on the cold side of the bar, (2) overdrafting—too many successive passes causing overfill on each side of the bloom or slab, (3) improper

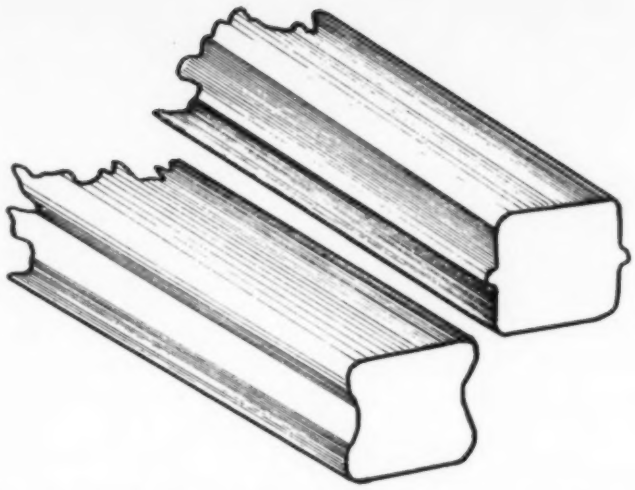


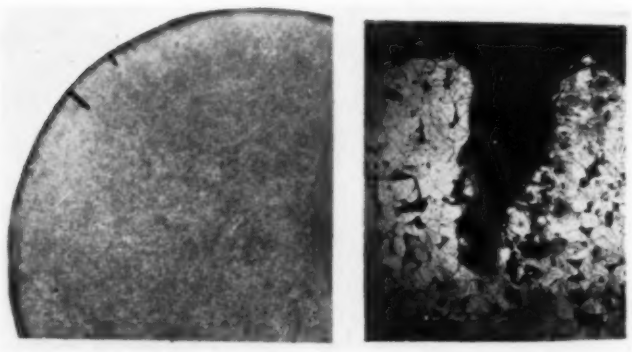
Figure 9 — Overfill is illustrated in the upper sketch and underfill is illustrated in the lower sketch.

guide setting. The resulting overfills cause laps which in depth are proportional to the amount of overfill.

Guide marks, Figure 8C, are more troublesome in the rolling of smaller sections. These marks are commonly caused by: (1) improper setting of guides (off center from the pass), (2) pick-up of steel on the guide surface, which in turn causes a cutting or scoring action on the side of the bloom. Such scoring results in deep seams, laps, a simple scratch, or it may not appear at all, depending upon the pass in which the original defect occurred. The use of roller guides wherever possible will help eliminate guide marks. In using stationary guides, the choice of suitable material, proper design and constant dressing of the contacting surface are essential.

Laps as shown in Figure 8D are longitudinal cracks or seams which usually extend over the entire length of the bar. They are commonly formed by rolling in overfills, deep scarfing marks, heavy scratches, etc. A lap cannot be easily identified from the outward appearance because of its close resemblance to a hair seam, but in cross-section, they are usually at some angle less than 90 degrees to the surface of the bar. In smaller round sizes this angle is often in the range of thirty to sixty degrees. It is not uncommon to attribute to poor rolling practice any seam which is not at 90 degrees to the surface of the billet. This is not necessarily true. A seam resulting from an opened up blow hole or sub-surface non-metallic, can take an angular aspect as a result of plastic flow in the rolling process. To differentiate between the various sources of laps requires microscopic study of the degree of decarburization, the presence of metallic and non-metallic segregates, the presence of trapped roll scale, etc. Since these characteristics vary from one plant to another, it is necessary for each plant to establish standards of identification by tracing the progress of known defects from their source.

Figure 10 — Seams shown result from deep scarfing. Depth of seams on left are 0.224 and 0.100 in. Seam on right sketch is about 0.020 in. and magnification of sketch on right is about 100 times more than that on left.



The occurrence of overfill, Figure 9A, can be attributed to excessive draft, incorrect heating, faulty mill alinement, or pass design. An overfill will normally result in a lap in the next passes and the size and position in the semi-finished product will usually indicate the pass in which it occurred. Underfill, Figure 9B, from insufficient draft, or faulty pass design, is somewhat less harmful than overfill. Although laps or seams can result, twists and turndowns occur more often, but the chance of obtaining a satisfactory product is greater than with overfill. The allowable degree of underfill in the final pass is determined by the end use of the product.

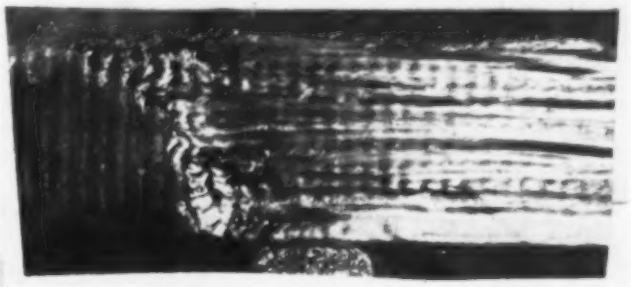


Figure 11 — Deep starting marks in scarfing will result in costly defects.

The various types of seams constitute the greatest source of defects in semi-finished products. The problem of determining their origin is often quite difficult, since their appearances are similar. However, in some cases it is possible to establish the cause of their formation by the shape or size and by macroscopic or microscopic examination. Mechanically made seams usually have a smooth, uniformly straight contour on the surface and sides of the seams. Seams from steel defects are more irregular unless the seam opens up very early in the rolling process, in which case the greater reduction elongates the seam until it appears quite straight. The degree of decarburization can be used as a guide to differentiate between types. A seam produced by a mill scratch is essentially free from decarburization, while a seam produced from an open crack in the original ingot or billet will be decarburized in the heating process. Seams may be produced as a result of sub-surface inclusions which break through the surface during rolling. The presence of these non-metallics is more obvious in an unpickled bar, since in the pickling process they tend to be removed. As mentioned previously, seams may result from sub-surface blow holes which have been washed open in the soaking pit, but they may also

break through the surface during rolling and in either case the areas adjoining the seam are usually associated with segregation. Brush seams resulting from rough rolls vary in depth depending on the degree of roughness and subsequent rolling. The acceptable degree of severity of brush seams depends on the end product, but they can be eliminated at the cost of roll life.

Another source of mechanical defect is known as grinding. This occurs in sectional passes when excessive pressure is exerted between the outer periphery of the pass and the bar. The forward speed of the bar is governed by surface contact with the roll at some average radius. If the lineal speed of the outer periphery of the roll is sufficiently greater, a shearing section results, and a thin sliver of metal is removed from the bar when (1) mill is out of line, (2) guides are out of line, (3) guides are too wide and permit bar to lean.

The importance of proper conditioning cannot be over emphasized. Defects as a result of poor conditioning can be eliminated by careful inspection, providing subsequent heating and rolling practices are satisfactory.

Figure 10 is the result of an experiment conducted to determine the effect on a semi-finished round of excessively deep scarfing in a bloom. In this case the areas of deep scarfing in the bloom were charted and the seams in the rounds traced back to the bloom. The heavy seams all occurred in positions showing deep scarfing. It is not intended to infer that these seams were a result of deep scarfing alone. There were, in fact, two contributing conditions; in the first place the deep scarfing gouges were insufficiently flared; second, the bloom was not heated evenly and the seams were formed on the cold side of the bloom. The elimination of either of the irregularities could have reduced the severity of the seams and possibly eliminated them.

Starting marks, Figure 11, result from inexperienced or careless scarfing and may lap in further rolling. They are formed when the starting angle between the cutting flame and surface of the bloom or billet is too great. Careful inspection after scarfing can correct this.

Figure 12 shows by a series of sketches how seams develop when high ridges remain between torch cuts. Figure 13 is a photograph of this condition after rolling into a semi-finished round.

The use of scarfing torch on grades sensitive to thermal shock is hazardous. On carbon grades of SAE 1040 and higher, scarfing should be done only when the steel is warm. The exact temperature required depends on the grade of the steel.

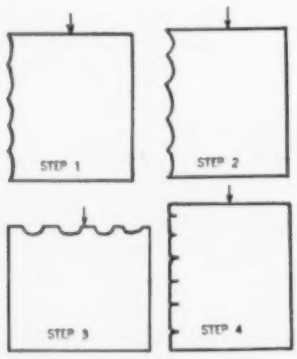


Figure 12 — Seams can form because of high ridges between scarfing torch cuts.

Figure 13 — Illustration shows the seams formed as illustrated by the sketch of Figure 12.

The sources of some of the more troublesome surface defects in semi-finished steel products have been indicated. Seams or laps can occur as a result of poor practice during almost any phase of the processing and identification of their source may require macroscopic, microscopic, or even experimental procedure. Defects incurred by poor heating practice are usually identified by visual inspection of their characteristic appearances.

The problem of surface failure due to steelmaking practice is one of steel cleanliness, deoxidation practice, sulphur reduction and pouring pit practice. The elimination of these sources of defects is most difficult to accomplish and usually requires considerable experimental work.

Seams, laps and cracks, as produced by rolling mill practice, are the result of incorrect pass design, mill or guide alinement, overdraft, underdraft and similar mechanical irregularities. Close inspection and supervision can minimize the occurrence of these defects.

The overall reduction of surface defects requires close cooperation between open hearth, rolling mill, conditioning yard and metallurgical departments. It is a problem involving more rapid identification of defects as to their source and training operating personnel to recognize them, so that corrective measures can be taken without delay.

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DISCUSSION

PRESENTED BY

J. H. LOGUE, Superintendent of Blooming Mills, Jones & Laughlin Steel Corp., Pittsburgh, Pa.

D. W. LLOYD, General Superintendent, Youngstown Sheet & Tube Co., Youngstown, Ohio.

L. H. Logue: The integration of modern steel mills, which has made possible the production of large tonnages of steel products at very low costs, is based upon fast handling of the steel and conservation of all possible heat. But one of the prices we must pay for the economies effected by this system is the inability to inspect the product after each step in the production cycle, and thus unequivocably assign responsibility for various defects in the semi-finished or finished product. When two or more departments are involved in steelmaking and processing, without opportunity to inspect the product as it leaves each department, determination of responsibility for defects may often become a case of "who done it?" As Mr. Lloyd has so ably said, "It is often quite impossible to determine the cause of defects from a postmortem examination of the semi-finished product, as defects from different causes may appear identical." This fact has been forcibly demonstrated in our plant.

We were plagued with what appeared to be mill laps in hot rolled bars after processing in our cold finishing department. An extensive study was undertaken to determine the cause. Billets were pickled and scarfed, repickled and rescarfed; rigidly inspected until we were positive that all billet defects had been removed, and then rolled on our merchant mill. The defects still showed up; sometimes in the hot rolled bars; sometimes in cold drawn bars; and even occasionally in bars that had been cold drawn from hot rolled bars that had been carefully inspected and were known to have been free of defects. Samples were taken at various steps in processing and tested. At one time the merchant mill was deliberately set to make an overfill in one of the early passes, which of course was lapped in the ensuing pass, and the product of this mill setting was analyzed. Of course the laps were apparent, and seemed to be similar to the defects which we had been encountering. Billets were sampled, etched and microphotographed. We found a surface seam ¼ in. deep. Scarfing would normally remove all open seams. However, under the open seam or crack there are certain weaknesses that penetrate deeper into the cross-section, and would not be noticeable to the scarfer, probably even after repickling. We believe that even after the removal of the open crack or seam on the conditioning bed, the demonstrated inherent weakness in the internal structure would be more prone to fail or break open in subsequent hot or cold working, and cause a rejection in either the hot rolled or cold rolled bar. Also a micro examination of the cold finished bar would reveal the ferrite banding which might appear as decarburization and thus be incorrectly identified as a hot mill lap.

In the field of rimmed and capped steels for automobile body stock, tin plate, etc., I would like to ask Mr. Lloyd a question. He has stated "Burned steel is due to a hot flame concentration which melts out from the ingot, the lower melting segregates." My question is: Should not the open hearth be expected to make ingots which are so free of segregates that they can stand the flame of normal soaking pit heating practice? Also Mr. Lloyd stated "A spongy ingot is created by washing away the surface of the metal and opening to oxidizing atmospheres the sub-surface blow holes. These oxidized surfaces will not weld together during rolling." I would like to raise these questions: Should we expect to obtain from normal open hearth practice rimmed ingots with thick enough skin to stand normal soaking pit heating? and what can be done to salvage thin skinned ingots that will happen occasionally in every open hearth shop? Can these abnormally thin skinned ingots be spotted in the open hearth and the soaking pit heater notified in advance so he can take special precautions to prevent washing off this abnormally thin skin. Also if the thin skinned heat is identified in time, what adjustments or changes in normal soaking pit procedure should the heater take to prevent washing and exposing blow holes? Another question I would like to ask: I have observed some ingots rolling on the blooming mill which had been carefully observed and had not been washed in the soaking pits; nevertheless the steel opened up in rolling and rolled out spongy, with the same finished appearance as ingots that had been washed in the pits and the blow holes exposed. Is it possible that some ingots are so thin skinned that the skin on being chilled from contact with the rolls and roll cooking water loses its plasticity and breaks open in rolling and thus presents a spongy appearance in the slabs?

D. W. Lloyd: In order to avoid "burned steel," the furnace gases must be closely controlled. Close attention must be paid to avoid flame impingement and care taken to insure against overheating. Appreciable concentrations of iron oxygen compounds are stable in steel only if there is no carbon present, and therefore burning takes place only after most of the carbon has been eliminated. This action may be neutralized by the control of furnace atmosphere.

No open hearth operator wants to produce rimmed heats which are abnormally thin skinned. If such be the case, the fault is generally found in the pouring practice and can be controlled by the addition of sodium floride, or some other equally good catalytic agent which will speed up the evolution of gases. Furnace temperatures have an effect on rimming rates, as well as mold coatings. Thin skinned ingots can generally be spotted by the soaking pit heater before charging.

The steel pourer certainly knows the heat poured is of good or bad rimming action by observation, and such information should be passed on to the rolling mill through the medium of observers, or on the heat manifest.

Salvage after burning can be accomplished only through the medium of burn-downs or by scarfing, provided the cracks do not extend so far into the slab or bloom as to require an excessive amount of surface removal. Such salvage is an economic problem in most shops and is, even if salvaged, a problem of application.

It has been observed that some heats are so thin skinned that a heavy scale formed in the soaking pits will expose them to the flame. Their appearance after rolling resembles burnt steel, but microscopic examination will reveal the absence of extreme decarburization.

KRUPP-PENN TESTS ON FRENCH MINETTE ORE

By

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. . . . the Krupp-Renn process has possibilities for ore beneficiation which may make it fit in with conventional iron-making procedures . . . .

▲ THE Krupp-Renn process is a method of recovering iron from low-grade siliceous iron ore under reducing conditions in a rotary kiln. It was developed by the German Krupp Co. during the early nineteen thirties, the initial large scale pilot plant at Borbeck, Germany being put into operation about 1934. The process was originally designed to recover metallic iron directly from unbeneficiated low-grade ores for use in steelmaking furnaces. Experience proved that, in effect, it was an ore beneficiation process, since its product was normally so high in sulfur that it could only be charged to the blast furnace.

To a certain extent the Krupp-Renn process operates on the same principle as the blast furnace, in that to obtain the desired separation of the metal from the gangue, the ore is first reduced, and then both the iron and the gangue are melted. Unlike the blast furnace, however, the metal never becomes completely molten and, in fact, is recovered in solid rather than liquid form, dispersed as rounded granules of metallic iron in the pasty, glassy slag flowing from the hot lower end of the kiln. To treat ore of this kind in a blast furnace would require a large amount of limestone to flux the silica in the gangue, and the resultant high slag volume would greatly increase coke consumption as well as decrease blast furnace capacity. In the blast furnace, as normally operated, most of the sulfur in the burden and fuel is held in the slag. In Krupp-Renn practice, much of it goes into the metal, and this fact is one of its main disadvantages.

The strongest point of the process is that the rotary kiln can be separately heated by the cheapest available fuel, which in Europe is usually pulverized coal. In addition to the heating fuel, a reducing agent is required, but since it does not need to have the large size and high strength required of blast furnace coke, any solid carbonaceous material can be used, such as coke breeze. An excess of reducing agent is necessary to hold the loss of unreduced iron in the slag to a minimum.

The hot, heavy viscous slag, together with its contained reduced iron granules and excess coke, is cooled with water sprays as it comes from the kiln and then is crushed dry and sent to dry magnetic separators which recover the reduced iron. The larger sizes of iron granules are of relatively high grade, but the smaller ones below about 25 mesh carry so much adherent slag that they are returned to the kiln.

The tests described in this article were undertaken as the result of an agreement between the French Institut de Recherches de la Siderurgie (IRSID) and the Czechoslovakian Steel Industry Administration. They were carried out in May 1949 by the Czech United Steels Co. in the Krupp-Renn rotary kiln installation at their Kraluv Dvur plant not far from Prague. Approximately 300 metric tons of French Minette ore from the Bazailles mine in Lorraine were processed. P. E. Henry was present during the carrying out of the tests as the representative of IRSID.

A brief description of the Kraluv Dvur plant, which was built during the German occupation, and its normal operation on Czech ores is given first, followed by details of the French ore tests. Various aspects of the process are then discussed and its possible adaptation to American conditions considered.

DESCRIPTION OF INSTALLATION

The kiln — The kiln itself is 60m (197 ft) long with an external diameter of 3.60m (11 ft-10 in.). It is mounted with a slope of 3 degrees and revolves at approximately one rpm. The lining in the upper part consists of ordinary firebrick (chamotte); a special alumino-silicate brick is used in the lower part. The latter normally becomes covered with a hard coating of sponge iron which acts as the actual lining surface.

Charging — Charge materials are kept in silos provided with bottom table feeders which discharge into a single hopper, motor operated scale car. Discharge of material from the silos is controlled electrically by the scale car operator from the car. As soon as a charge is made up it is dumped into a vertical, conical mixing hopper equipped with central paddles. A certain amount of metallic return fines and kiln flue dust are added directly to the mixer without being weighed or analyzed, as mentioned later. The mixed charge is raised by a bucket elevator which discharges into a pipe feeding the upper end of the kiln. A small jet of compressed air in

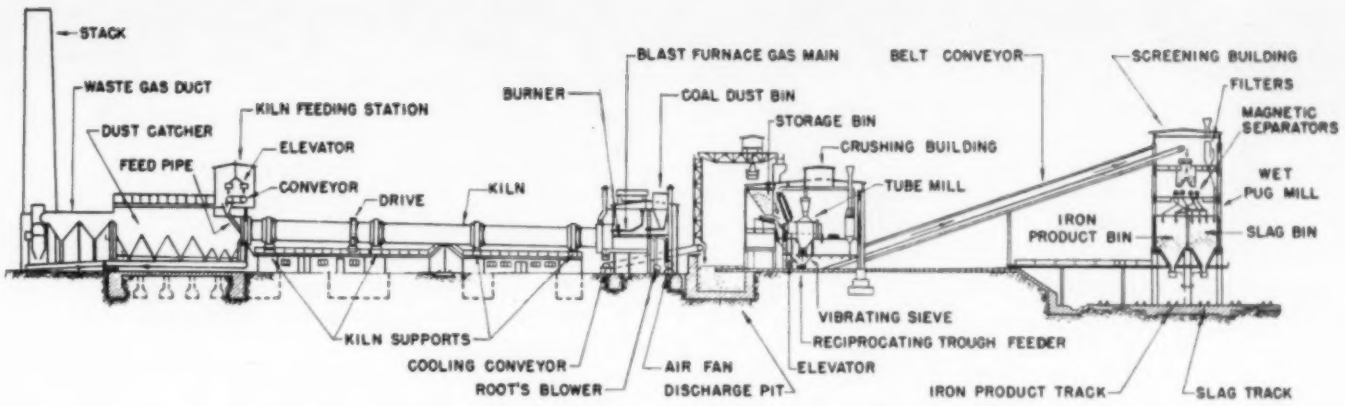

Figure 1 — Typical cross section of Krupp-Renn plant at Watenstedt.

the lower (discharge) end of the feed pipe prevents escape of any kiln gas up the pipe. The gas is under a slight pressure at this point due to its high temperature and the fact that the kiln is forced draft fired from its lower end with pulverized fuel. Figure 1 shows a typical cross section through a similar unit at Watenstedt, Germany that is almost identical with the Czech layout.

Normal burden — The normal burden consists of a mixture of low-grade local Czech ores — Krusna Hora and Zdice — flue dust from the two Kraluv Dvur blast furnaces (of 220 and 240 tons per day pig iron capacity), and coke breeze. The ores are oolitic, of silurian age, and very lean. They are high in silica and low in lime.

Analyses of the normal burden materials and of the slag and metal produced are given in Table I.

TABLE I

Composition of Ores and Products

Normal Czech Operation

Dry Basis

	Krusna hora crude, per cent	Roasted zdice, per cent	Slag, per cent	Metal, per cent
Fe	30.0	26.0	...	...
P	0.5	1.0	...	1.4-1.6
Mn	0.1	0.1	...	0.1
SiO_2	25-26	24.0	60.0	...
Al_2O	10.0	10.0	20-25	...
CaO	2.0	2.4	6-7	...
MgO	1.5	1.6	5-6	...
S	0.3	0.5	...	0.5-1.0
C	...	...	...	0.5-0.8
Si	...	...	...	0.1

When the above Czech ore analyses are not strictly exact they are believed to be approximately correct.

Slag composition — A lime-silica (CaO/SiO_2) ratio of approximately 0.09 must be maintained. This sometimes drops to 0.07, but the operators, never having had to go lower, do not know whether or not a still lower figure would cause trouble. The ratio can go up to 0.12, but this increases fuel consumption as the slag has to be hotter. Normal operation is possible up to 0.16; any higher ratio causes ringing about 20m (66 ft) up from the burner end of the kiln where slag formation first begins.

The viscosity, or rather the fluidity, of the complex glass, full of inclusions, which constitutes the product of the kiln, plays a very important role in the process, but it has never been studied systematically. The furnace men have been content with their own empirical opinions formed from past practice. The optimum slag composition for smooth operation on Czech ore based on their experience has already been given in Table I.

Average fuel consumption is:

	Per cent of ore wt.
Pulverized coal — 280-290 Kg/metric ton Krupp-Renn product (560-580 lb/net ton)	8–10
Coke breeze—900-950 Kg/metric ton Krupp-Renn product (1800-1900 lb/net ton)	25–27

Fuels — The quality of the coal and breeze varies. The coal available for pulverizing is often very poor; up to 36 per cent ash and 9 per cent water. The coke breeze also has up to 19 per cent ash and 18 per cent water. Averages are 30 per cent ash and 7 per cent water for the coal and 14 per cent ash and 14 per cent water for the breeze can be used as averages. The Czech coal that was fired during the French ore tests was somewhat better than normal.

The slag coming from the furnace is thick and viscous and contains inclusions of metallic iron and bits of unburnt coke. The presence of an excess of coke is essential. The slag flows out of the lower end of the kiln onto a steel pan conveyor which carries it to a pit where it is sprayed with water. It is reclaimed from the pit by a clam shell bucket.

In normal practice on local ores the temperature of the slag leaving the furnace is 1280-1300 C (2330-2370 F). Four pyrometers are installed in the kiln lining; one at 20m (66 ft) and one at 45m (148 ft) up from the lower end, plus one at the upper end, and one at the base of the stack. These give temperatures of approximately 600, 450, 350 and 250 C (1110, 840, 660 and 480 F) respectively, as shown graphically later on in Figure 3.

A large dust settling chamber is located between the upper end of the kiln and the stack. The flue gas leaving the furnace contains from 18½ to 20 per cent of CO_2.

The equipment in the crushing, screening and magnetic separation plant was built by the Krupp Grusonwerke of Magdebourg.

Magnetic separation — The crude, glassy slag is ball milled prior to magnetic separation. A single conical type ball mill is used, mounted in closed circuit with screens so that the mill receives only plus 10mm (0.4 in.)

material. The discharge opening of the mill contains a bar screen which holds back all reduced iron balls larger than 50mm (2 in.) in diameter. These act as grinding balls and are recovered from time to time when the mill is emptied to remove worn out balls. Following the ball mill there are four screens — with 2.5, 2.0, 1.75 and 0.75mm (8, 9, 10 and 24 mesh) openings for feeding 5 drum-type dry magnetic separators. The magnetic separators themselves function unsatisfactorily. They are poorly fed, the feed covering only a fraction of the drum surface, and the layer on even this fraction is far too thick. On the other hand, two new "natural resonance" type vibrating screens appeared to be quite effective, their smooth operation making a very good impression. They are spring suspended units and are adjusted so that their natural period of vibration under load corresponds with that imparted to them by their vibrating unit.

The non-magnetic slag tailings are recombined arbitrarily into three commercial sizes of crushed slag, roughly plus 2mm (9 mesh), minus 2mm (—9 mesh), and a mixture of the two. Similarly the metallic concentrate is recovered in three classifications, approximately minus 0.75mm, 0.75 to 2mm, and plus 2mm (24, 24 to 9, and plus 9 mesh). This separation can only be made discontinuously as follows. The circulating load is allowed to build up for a time in the ball mill circuit, which it tends to do due to the fact that the iron granules are not ground. When the load gets too high, the system is relieved of its excess iron by "simplifying" the circuit; i.e. by straight through rather than closed circuit operation. By this crude makeshift, a mixture of the various sized products is obtained. The transition from full closed circuit operation to the simplified one is based on the foreman's judgment and experience, guided by the load on the bucket elevator motor, which increases as the weight of the loaded buckets rises with increased percentage of metal.

The fine minus 0.75mm (24 mesh) metallic concentrates are very impure, containing only 70 to 75 per cent iron. Normally they are returned to the kiln feed mixing hopper without being weighed, but during the French ore tests they were kept separate.

A diagrammatic flow sheet of the process is given in Figure 2.

Products — The products made consist of three commercial grades or sizes of crushed slag, plus an iron concentrate made up of granules of all sizes. The slag is used in concrete and for sanding snowy roads in winter. The iron granules range from 0.75mm (24 mesh) up to balls as large as 50 to 100mm (2 to 4 in.) in diameter, and their average percentage composition under normal Czech practice is:

C	0.5-0.8	P	1.4-1.6
Si	0.1	S	0.5-1.0
Mn	0.1		

The metal produced (plus 0.75mm) is shipped to, and charged into the blast furnaces at Kladno. This Krupp-Renn operation is therefore an ore beneficiation one which raises the grade of the ore from 28 to about 92 to 93 per cent Fe.

PRIOR CAMPAIGNS

When the Bazailles ore tests were run, the Krupp-Renn kiln was nearing the end of its sixth campaign

Figure 2 — Schematic flow sheet of Krupp-Renn process as used at the Kraluv-Dvur plant.

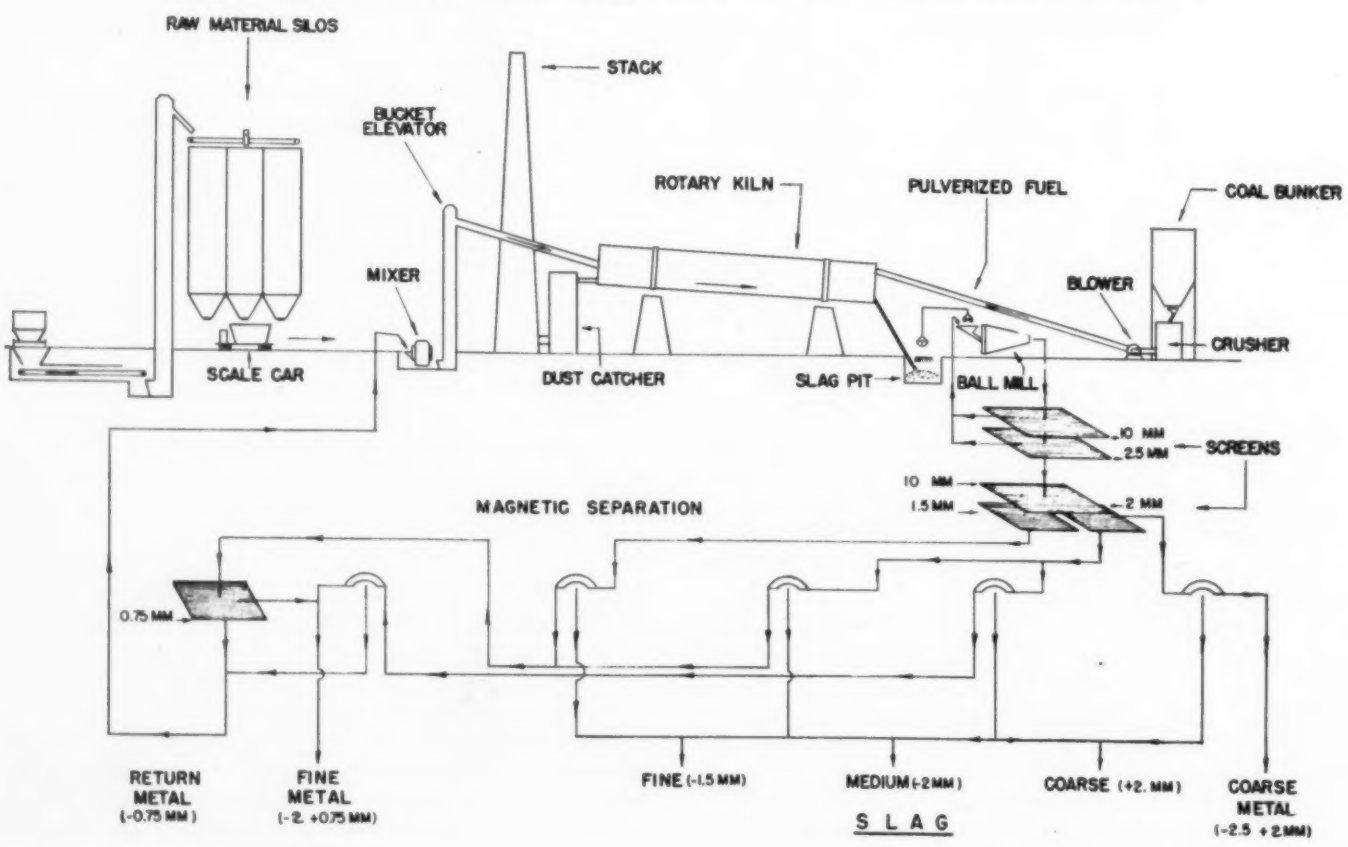

TABLE II

Data on Previous Campaigns

Campaign No. and dates	Time in days	Minor delays in hours†	Kiln outages in days	Krupp-Renn product — M tons	
				Total for campaign	Average per actual operating day
I					
Feb. 6, 1946 to June 28, 1946	142	30	..	10,459	73.7
Relining	(76)				
II					
Sept. 12, 1946 to Feb. 17, 1947	158	27	4	10,812	70.2
Relining	(50)				
III					
Apr. 8, 1947 to Aug. 14, 1947	128	48	..	9,087	71.0
Relining	(56)				
IV					
Oct. 9, 1947 to Mar. 21, 1948	164	143	..	12,032	73.3
Relining	(45)				
V					
May 5, 1948 to Nov. 1, 1948	180	133	15	11,789	71.4
Relining	(55)				
VI					
Start Dec. 26, 1948	.....	.....	.....	.....	.....
Totals	772 Days	381 Hr	19 Days	54,179 Tons	72.0* Tons

*Total campaign days less major kiln outages = 753 days. $\frac{54,179}{753} = 72.0$ Tons/Day.

†"Minor delays" are those due to power failure, auxiliary equipment trouble, or the need for minor repairs to the kiln itself that can be made without completely cooling it down and emptying it. "Kiln outages" are when the kiln is cooled down after being run empty, but is not completely relined; i.e. repair of a local lining failure without disturbance of the remainder. The long 15-day outage of the fifth campaign for example was due to such a localized lining failure.

since the Germans left in the early spring of 1945. Details of the first five campaigns are given in Table II.

The ratio of campaign days in operation to total days gives a kiln availability figure of 71.4 per cent. From information obtained from other sources, this is very much higher than was ever obtained in either Germany or Japan.

The sixth campaign, which started on December 26, 1948, continued operating on local ores beyond the end of the Minette ore tests which were completed on June 1, 1949. The kiln showed no signs of failure, but the lining had become thin over the lower 10m (33 ft) and the shell had to be sprayed with water to keep it below a red heat. However the operators said the lining would undoubtedly have lasted at least through June, which have made a campaign of 186 days, but for the fact that they were scheduled to shut down on June 11 so as to make better use of the work's maintenance equipment. If they did shut down on June 11 the sixth campaign lasted 167 days.

Yield — According to the data in Table II and from other information it appears that on the average the 72 metric tons of reduced iron containing 92 per cent Fe that were obtained per day came from 270 tons of 28 per cent Fe ore charged. This gives a yield of approximately 88.5 per cent — which however is a rather uncertain figure. Assuming a slag volume under Czech practice of about 150 per cent, and the average total Fe found in the slag from the French ore tests (which was below 5 per cent) the loss of iron in the slag would amount to only 7½ per cent.

Total power consumption during normal operation at Kraluv-Dvur runs 100-105 kwhr per ton of product, a figure that includes crushing the ore and pulverizing the coal for the kiln. The installed capacity of the electric motors of the various sections of the Krupp-Renn plant are given in Table III.

TABLE III

Installed Capacity of Electric Motors

	Kw	Hp
Ore crusher	56	75
Coal pulverizer	101	135
Scale car	3	4
Charging facilities — total	16	21½
Kiln drive	113	150
Discharging facilities — total	31	41½
Slag ball mill	157	210
Magnetic separators — total	47	63
	524 kw	700 hp
	524	700

A power consumption of approximately 100 kwhr per ton for 72 tons of iron granules per day, or 7200 kwhr per 24 hours, is equivalent to a load factor of roughly 60 per cent on the above installed motors.

Force — The normal force for continuous operation with local ore consists of 3 foremen and 41 men per day, as shown in Table IV.

Relining — Not counting the foremen, the above force consists of 11 skilled men and 30 laborers. During relining, half the men work on cleaning up and minor repairs, while the other half are on leave. The major part of the relining work is done by three shifts of bricklayers consisting of 4 men each, a mason and 3 helpers. Mechanical repairs are carried out by the general plant maintenance shops, which supply from 6000 to 7000 man hours of labor per relining, including the bricklayers just mentioned.

TABLE IV

Working Force

	Number of shifts	Men per shift	Total men
Turn foremen	3	1	3
Overhead crane — silo filling	2	1	2
Ore preparation plant	2	2	4
Coal pulverizing	2	1	2
Scale car	3	1	3
Kiln charging	3	1	3
Kiln operation	3	3	9
Overhead crane — slag pit	3	1	3
Slag ball mill	2	1	2
Ball mill (maintenance)	1	2	2
Magnetic separation	3	1	3
Product storage	1	1	1
Replacements for days off and sickness			7
Totals		16	44

The major part of the work required is the complete replacement of the lining over the lower 15 to 20m (50-65 ft) of the kiln plus some minor local patching farther up. These minor local lining repairs are made for various reasons; brick falls, scaling of the lining, thinning of the lining to a point where the shell is likely to suffer heat damage, formation of a hard crust of sponge iron which gradually grows thicker, reducing the kiln diameter.

Ring formation — The thinning of the lining occurs in the highly heated zone, starting at a point where not much iron has yet been reduced to metal. Still farther up the kiln there is danger of ring formation, but in normal operation with local ores, any rings that form are of little importance, as they are easily removed by increasing the amount of breeze fed and lengthening the pulverized coal flame. Ring formation at this point as a matter of fact tends to help protect the lining in the critical zone where the first pasty slag begins to form.

This whole matter of ring formation is critical for the Krupp-Renn process, and whether or not their formation can be controlled depends on the early, low temperature, slag forming characteristics of the gangue in the ore. An ore with a gangue that tends to soften and fuse too far up in the kiln is likely to form rings that cannot be melted down. What is needed apparently is a relatively refractory gangue with a short fusion range, which melts only after the iron in it has been nearly completely reduced.

While the data given earlier for normal Czech operation is not sufficiently complete and detailed to permit any very accurate estimate of the economic value of the process, a production cost estimate based on certain assumptions as to its possible application to American conditions is developed and discussed later.

FRENCH ORE TESTS

Fifteen carloads of L.4 seam ore from the Bazailles mine, crushed below 10mm in size and weighing 323 metric tons was shipped from France. As one 22-ton car arrived too late the test was carried out on 301 tons. Table VI gives a number of different analyses of the ore and of the other raw materials used. The disagreement shown in the table between the three different sets of analyses of the same 300-ton shipment emphasizes the difficulty of accurately sampling any appreciable quantity of iron ore.

The two most important factors in any ore to be used for the Krupp-Renn process are the lime-silica and the silica-alumina ratios. Table V shows the values for

TABLE V

Comparison of Lime/Silica and Lime/Alumina Ratios

(Based on data of Table VI)

	CaO/SiO_2	SiO_2/Al_2O_3
Bazailles — First analysis	0.13	5.1
Bazailles — Second analysis	0.13	5.2
Bazailles — Third analysis	0.12	.....
Krusna hora	0.08	2.5
Zdice (roasted)	0.10	2.4

Bazailles ore compared to the normal Czech ores.

The French ore is richer in iron, more basic and less aluminous than the Czech. The possibility of adding either silica sand or bauxite to the French ore had been considered in case it gave trouble in the kiln, but this was not necessary. The tests showed that the process was more flexible than the Czech engineers had thought; they had been afraid that the slag would either not flow at all, or only with difficulty.

Fuel — Analyses of the coke breeze and coal used are also given in Table VI; it can be seen that the Czech coal used during the tests was much better than that normally received at the plant. The coke breeze came from Czech gas works and contained pieces of coke up to 10mm in size.

The Bazailles ore had been crushed down to 10mm in France, but was further reduced to 5mm in a roll crusher at Kraluv Dvur, as the operators are satisfied that 5mm (1/5 in.) material is best for the process.

Burdens — In order to observe the effect of the French ore on the operation of the kiln, 50 per cent of it was first charged mixed with 50 per cent of local ore. The proportion was then increased until French ore alone was used, after which the amount of breeze in the burden was varied.

Because of these changes six different burdens were used in all. Complete data on the different burdens, the number of charges of each, and the times they were used, are given in Table VII. (Clock times in Table VII are given in hours and decimal fractions of an hour.) Table VII shows that 36¼ hours elapsed between the first and last charge of French ore and that 145 charges in all contained some French ore.

The tonnage figures of Table VII show satisfactory agreement, because the weight of Bazailles ore charged comes to 298.8 tons, while the railroad car weights showed 301.0 tons, a difference of less than 1 per cent. During the time the kiln was operating on 100 per cent Bazailles ore, 213.6 tons of it were charged together with 64.4 tons of gas coke breeze, which averages 301 kg (665 lb) of breeze per metric ton of ore.

Insufficient French ore was available to reach and maintain stable conditions in the kiln for a long enough time to be sure that they would not be interrupted by secondary effects, such as ring formation too far up the

TABLE VI

Analyses of Raw Materials and Fuels

French Ore Tests

	French Bazailles Ore — L.4			Czech coke breeze		Czech pulverized coal	
	Lot sent to Kraluv Dvur		As sampled at Kraluv Dvur, percent	Coke (Dried @ 100 C), per cent	Coke ash, per cent	Coal (Dried @ 100 C) per cent	Coal ash, per cent
	Preliminary sample, per cent	Another sample, per cent					
Fe	36.1	35.3	34.0	.....	6.25	.....	4.0
P	0.72	2.25	.....	.....	.....	.....	.....
Mn	0.35	0.38	.....	.....	0.19	.....	0.08
SiO_2	24.00	21.3	25.4	.....	51.36	.....	54.04
Al_2O_3	4.7	4.1	.....	.....	30.90	.....	35.10
CaO	3.2	2.75	3.13	.....	3.28	.....	1.52
MgO	2.0	2.40	.....	.....	1.97	.....	0.80
S	0.06	0.10	.....	.....	.....	.....	.....
H_2O	7.2	13.5	.....	.....	.....	.....	.....
CO_2	1.1		.....	.....	.....	.....	.....
FeO	11.3	12.7	.....	.....	.....	.....	.....
Fe_2O_3	39.0	36.6	.....	.....	8.92	.....	5.72
TiO_2	.....	0.60	.....	.....	.....	.....	.....
Alkalies	.....	.....	.....	.....	3.28	.....	2.65
Vol. matter	.....	.....	.....	3.30	.....	34.35	.....
Ash	.....	.....	.....	17.9	.....	9.20	.....
Fixed carbon	.....	.....	.....	78.8	.....	56.45	.....

kiln to be easily melted out, or too infusible to be removed by a little stronger firing, as experience proves can be done with the local ores. Some 2000 tons of ore, as originally requested by the Czech authorities, would have been necessary to completely determine all operating conditions. Nevertheless, the practical opinion of the Czech engineers and furnacemen was that such difficulties need not be feared. On the other hand, it is impossible to say whether the length of the kiln campaign would be as long with the Bazailles as with local ore.

Kiln operation during the test — Details of furnace operation during the test runs are plotted in Figure 3, which shows powdered coal consumption, kiln lining and slag temperatures, the flue gas analyses (as registered by the Mono apparatus), and the burden changes. The figure shows clearly how often the amount of pulverized coal used was changed. Its consumption for each of the six burdens is given in Table VII. The great variation shows that thermally stable operating conditions were not reached during the tests.

When the temperature at the discharge end of the kiln, and therefore of the slag product, varies, there are two courses of action open; either the amount of coke breeze in the charge can be changed, or the amount of pulverized coal can be varied. The effect of the first action is necessarily slow because the charge takes 11 to 12 hours to pass through the kiln. The effect of a change in the amount of pulverized coal fired is immediate. This difference between the two courses of action makes it extremely difficult for the furnacemen to control kiln operation by his "hunches" or subjective impression.

During the time burdens No. 3 to 6 containing only

TABLE VII

French Ore Tests

Composition of Burdens, Sequence of Burden Changes and Tonnages of Ores and Fuels Charged

Date 1949	Time	Burden number	Hours burden charged	Number of charges	Composition of burdens — Kg/charge				Total weight of burden plus coke, Kg	Total tons of ore charged			Total coke charged	Pulverized coal consumption	
					Bazailles ore	Krusna Hora ore	Roasted Zdice ore	Coke breeze		Bazailles	Krusna Hora	Zdice		Kg per hr	Total Kg
May 26	11:00 pm	I	6.50	26	1200	600	600	680	3080	31.2	15.6	15.6	17.7	1026	6,669
May 27	5:30 am	II	7.50	30	1800	300	300	680	3080	54.0	9.0	9.0	20.4	615	4,614
May 27	1:00 pm	III	1.75	7	2400	...	...	680	3080	16.8	...	...	4.8	954	1,670
May 27	2:45 pm	IV	8.25	33	2400	...	...	720	3120	79.2	...	...	23.8	1062	8,764
May 27	11:00 pm	V	7.00	28	2400	...	...	740	3140	67.2	...	...	20.7	783	5,483
May 28	6:00 am	VI	5.25	21	2400	...	...	720	3120	50.4	...	...	15.1	880	4,621
May 28	11:15 am	end	...	...	...	...	...	...	...	...	...	...	...	...	...
Totals	.....	.....	36.25	145						298.8	24.6	24.6	102.5 Average	879	31,821

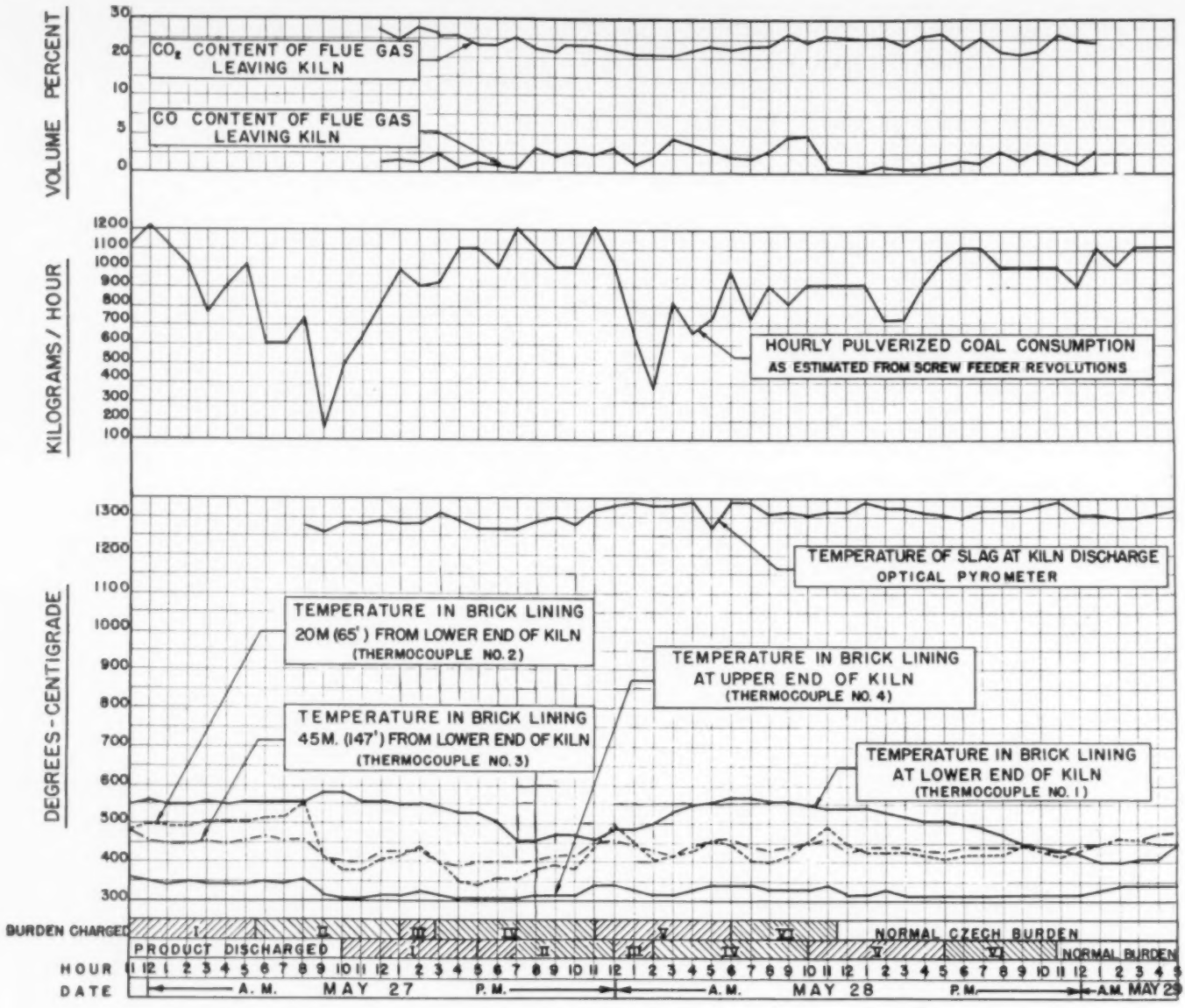

Figure 3 — Charts give data on flue gas analysis, fuel consumption, slag and kiln temperatures for the French ore tests on the Krupp-Renn process.

French ore were being charged to the kiln, a period of 22¼ hours, 20,540 kg of pulverized coal were burned, or an average of 923 kg (2038 lb) per hour. During the time the same burdens containing all French ore were being discharged from the kiln, a shift of 11½ hours, the fuel consumption over the subsequent 22¼ hour period was 19,410 kg or 873 kg hr. Although neither of these figures is very precise, their average, 898 kg/hr, should be close enough; it indicates that during operation with the French ore, about 5 per cent more actual fuel was used per hour than in normal Czech practice (855 kg/hr). As mentioned earlier, the coal available for the tests was somewhat better than average.

Upon exhaustion of the French ore, normal operation with a charge consisting of the following was resumed.

Coke breeze	780 Kg
Krusna Hora ore	1600 Kg
Zdice ore	300 Kg
Return fines	300 Kg

The "return fines" were not recirculated during the tests because the French products were all saved for separate processing later. Since the granulating pit could not be cleaned out, it seemed best to put the return fines aside during the test for subsequent weighing, sampling, and analysis, rather than to complicate matters by charging return fines from other ores. In this instance again it is obvious that a much longer test run would have been necessary to reach stable operating conditions so that the materials in all stages of the process would correspond to the French ore charged.

Flue gas — During most of the test, the waste spent gas leaving the kiln was analyzed for CO and CO_2 by a permanently installed Mono instrument, which the operators normally did not keep in service. The hourly readings are those plotted in Figure 3. In addition to the values shown in the figure, complete gas analyses were made of two samples of the gas leaving the kiln on May 28th at 12-25 and 2:00 p.m. These analyses, made by an Orsat apparatus, are given in Table VIII, compared with the Mono values.

The more complete Orsat analyses do not agree with those made simultaneously by the Mono instrument.

TABLE VIII

Gas Analyses

	May 28, 1949			
	12:25 p.m.		2:00 p.m.	
	Orsat, per cent	Mono, per cent	Orsat, per cent	Mono, per cent
CO_2	19.7	25.5	21.4	25.4
CO	2.3	1.0	2.6	1.2
H_2	5.1	.....	3.5	.....
CH_4	0.2	.....	0.4	.....
O_2	nil	.....	nil	.....
N_2 (by difference)	72.7	.....	72.1	.....

The Mono instrument appears to regularly record too much CO_2 and not enough CO; the complete analyses are believed to be more accurate. The curves in Figure 3 are presented only to give an idea of the very low range of variation in the gas composition. All gas samples were taken from the dust settling chamber adjacent to the upper end of the kiln.

Samples of the glassy slag leaving the furnace were taken hourly by a spoon from 6:00 a.m. on May 27 up until 4:00 p.m. on May 28 and sent to France for study and analysis. The results (including some after heavy density media separation) are given in Table IX and X.

Product — In order to obtain finished products that would be representative of French ore alone without admixture of other ores, a portion of the slag from the furnace was piled separately on May 28 from 3:00 a.m. until 7:00 p.m. From Figure 3 it can be seen that the product during this period came entirely from French ore. The ball mill and magnetic separator circuit was then completely emptied and a part of the separately piled slag was processed on May 31, the operation lasting from 1:00 to 10:00 p.m. All products were sampled the next day, June 1st.

To avoid any admixture of local or mixed slag only a portion of the product from the French ore could be crushed and magnetically separated. It was also desir-

TABLE IX

Composition of Slags and K-R Metal Produced — French Ore Tests

	Crude slag, percentages			Slag separated by heavy media* S.g. between 1.8 and 2.88 (percentages)			Single K-R pellets or balls (percentages)			
	Fine —2 mm	Medium mixture	Large +2 mm	Fine	Medium	Large	25 mm diam	15 mm diam	Sample of fine grains	Average of 3 column to left
C	13.2	8.90	5.30	6.25	1.30	0.65	0.73	0.89	0.79	0.80
Si	.....	.....	.....	.....	.....	.....	0.07	0.05	0.09	0.07
Mn	.....	.....	.....	.....	.....	.....	0.13	0.05	0.08	0.09
P	.....	.....	.....	.....	.....	.....	1.93	1.92	1.83	1.89
S	0.24	0.19	0.17	0.64	0.51	0.61	0.67	0.69	0.68	0.68
SiO_2	54.90	57.65	59.0	55.35	59.10	57.90	.....	.....	.....	.....
Al_2O_3	15.65	14.75	15.35	16.60	16.60	17.30	.....	.....	.....	.....
CaO	6.87	7.16	7.65	9.72	10.30	10.60	.....	.....	.....	.....
MgO	4.71	4.0	4.52	4.32	4.73	4.51	.....	.....	.....	.....
P_2O_5	0.48	0.58	0.41	0.38	0.27	0.26	.....	.....	.....	.....
MnO	0.88	0.80	0.84	0.60	0.95	1.40	.....	.....	.....	.....
TiO_2	0.30	0.35	0.40	0.94	0.97	1.10	.....	.....	.....	.....
FeO	1.00	0.61	1.40	0.57	0.60	0.78	.....	.....	.....	.....
Fe_2O_3	4.57	3.07	2.85	2.95	4.10	4.15	.....	.....	.....	.....
Fe	1.13	1.60	1.75	0.84	0.49	0.67	.....	.....	.....	.....
(Total Fe)	(5.09)	(4.22)	(4.83)	(3.34)	(3.38)	(4.17)	.....	.....	.....	.....

*The slag lighter than 1.8 s.g. contained most of the excess carbon.
The slag heavier than 2.88 s.g. consisted of particles containing metallic inclusions.

TABLE X

Variation of Composition of the K-R Pellets with Size

Size in mm		Weight per cent	Per cent Fe	Per cent of total Fe	Per cent S	Per cent of total S	Per cent P	Per cent of total P
Fines — under 2 mm	+2	20.9	94.80	21.28	0.72	23.77	1.45	22.63
	—2	79.1	92.67	78.72	0.61	76.23	1.31	77.37
Total and average		100.00	93.11	100.00	0.63	100.00	1.34	100.00
Coarse — over 2 mm	+30	0.50	98.2	0.53	0.69	0.58	0.93	0.29
	—30 +15	3.08	98.55	3.24	0.44	2.25	0.71	1.37
	—15 + 8	7.75	96.95	8.03	0.70	9.01	1.34	6.49
	— 8 + 4	20.72	93.9	20.79	0.65	22.37	1.68	21.74
	— 4 + 2	65.06	92.8	64.52	0.58	62.67	1.70	69.10
	— 2	2.89	93.6	2.89	0.65	3.12	0.56	1.01
Total and average		100.00	93.58	100.00	0.60	100.00	1.60	100.00

able not to hold up the normal operation of the plant too long.

All the metal obtained by processing the French slag was weighed. It consisted of 31.2 tons of reduced iron product and 8.6 tons of return fines. Of the product 46.8 per cent was between 0.75 and 2.0mm in size while 53.2 per cent of it was coarser, over 2.0mm. A particle size analysis made in France gave the following results:

TABLE XI

Screen Analysis of Metallic Product

Size range in mm	Coarse product, per cent	Fine product, per cent	Weighted composite average, per cent
Plus 30	0.8	....	0.4
Minus 30 plus 15	6.1	....	3.2
Minus 15 plus 8	11.9	....	6.3
Minus 8 plus 4	65.0	37.3	52.1
Minus 4 plus 2	15.4	53.2	33.3
Minus 2	0.8	9.2	4.7
	100.0	100.0	100.0

Table XI shows that 85 per cent of the product is between 2 and 8mm in size.

Slag — The composition of the slag and return fines, as well as chemical analyses of the metal can be found in Table IX and X.

It was not possible to weigh the slags produced from the different burdens. Local facilities were not readily available and weighing would also have entailed too long an interruption of regular production. Care was taken however to be sure that the size of all slag samples and return metal fines (—0.75mm) were large enough to be representative.

The analyses do not permit making an accurate material balance of the process. Better figures could only have been obtained by processing a much greater quantity of French ore and operating until all local ore was displaced throughout the system, including the entire recycled flue dust and return fines. It would then have been possible, once stable operating conditions had been established, to weigh all products for a period of at least 48 hours.

Practice on local ore yields roughly 38.5 per cent of metal and 61.5 per cent of slag, including coke ash.

DISCUSSION OF RESULTS

There are a few observations on actual test procedure that should be made to aid in the proper interpretation of the results. They are given without any attempt either to evaluate the Krupp-Renn process or to outline any particular chemical or thermodynamic theories as to what happens.

Most of the data presented has only a relative value. The kiln pyrometer readings merely indicated the temperature of four points in the lining and not the temperature of either the gas or the charge. The optical temperatures of the discharging slag were subject to all the uncertainties of such measurements. No attempt was made to make the readings more accurate by standardization of the instruments or by check readings. The "Mono" gas analyses are somewhat doubtful, as can be seen by comparison with the two Orsat analyses that were made; and even the latter should be used with due caution. The amount of coal pulverized was estimated from the rpm's of the two burner screw feeders. Although the coal pulverized was supposed to be dry (dried during preparation) the consumption figures were adjusted to a 10 per cent moisture basis to balance the material accounts.

Slag appearance — The appearance of the slag at the kiln discharge changed slightly on the French burden. It was a little thicker and had less of a tendency to pull threads as it fell from the kiln onto the discharge conveyor. This indicated that it was both more viscous and possessed a higher surface tension. These were the things that at times led the operators to increase the coke ratio and the pulverized coal feed. The proper balance between these two fuels was difficult to determine, because, as previously mentioned, the effect of one was immediate, while that of the other was greatly delayed. A sound practice can only be developed over a considerable period of time with a constant burden of the same ores. The fuel consumption could probably have been reduced by charging some clay; the addition of 8 per cent (by weight of the ore) of a 50 per cent alumina clay was suggested. Ferruginous bauxite or waste alumina plant residues ("red mud") with a high ratio of alumina to silica could perhaps be used.

Optimum slag composition — This brings up the problem of the best slag composition. What is the best slag depends on the point of view: lining life, high fluidity to save fuel, or the quality of the metal produced, particularly its sulfur content. All these factors make the problem very complex. The Kraluv Dvur engineers proposed to solve it empirically by trial and error. Preliminary physical chemistry studies in a case like this would undoubtedly greatly narrow the range of full scale tests required, shorten the time required for them, and lead more surely to the desired result.

It seems quite certain that the slag must contain an excess of coke; this is set by the Kraluv Dvur engineers at 10 to 15 per cent and the reported slag analyses confirm this. The excess coke is needed to keep the slag sufficiently reducing so that only a minor amount of iron oxide remains in it. The presence of excess carbon is indicated by blue flames that break out all over the slag on the discharge conveyor. A method of determining the true oxide reducing power of a slag would be of great interest, particularly for the Krupp-Renn process.

In the American (Laramie, Wyoming—Bureau of Mines) rotary kiln sponge iron process, a much greater amount of solid fuel is used, and the excess recovered. This would appear to be feasible even when no great excess is used, either by wet methods, such as a Driessen cone, or over an air table.

Recirculation possibilities — Recirculation of a portion of the slag might perhaps be used as a means of stabilizing the operation of the kiln. It might also be used to increase the content of certain elements in the circuit until the slag has quite different characteristics from the original product. Titania, which increases the fluidity of very acid slags such as those at Kraluv Dvur, might possibly be built up in this way. This might avoid the addition of alumina and at the same time permit operation at a lower temperature with some saving in

fuel. In the American kiln process (Laramie), a certain amount of slag is in fact recirculated, but this is mainly to recover its metallic Fe content, a further important consideration.

Rotary kiln — Operating practice at Kraluv Dvur discloses all the drawbacks of the rotary kiln. There is practically no way of controlling what goes on in the middle of the charge where most of the reduction takes place. The rotation segregates the kiln contents, and creates temperature differences which are damaging in every way; i.e. fuel consumption, lining life, product quality. The most harmful segregation of all is that of the coke; it can be reduced somewhat by using finer breeze. The Kraluv Dvur engineers would like to use a breeze of constant grain size distribution containing nothing larger than 5mm, instead of the breeze which they receive from various gas works, which is unsized and contains particles up to 10mm in diameter.

Czech practice compared—Considering the inexperience of the German builders of the Kraluv Dvur plant and the poorness of some of the equipment, especially the magnetic separators, the results that the Czech operators have been able to achieve is quite remarkable. From what is known of Krupp-Renn operations in Germany and Japan, it can be assumed that the Kraluv Dvur plant runs far better than the others, and is in fact the only Krupp-Renn operation on which any opinion as to the value of the process and its field of usefulness can safely be based.

The Kraluv Dvur engineers think that they can increase furnace availability considerably above the 72 per cent figure, as well as increase the length of the campaign and reduce the relining cost. They see as the next step a 70m furnace instead of 60m, and an increase in shell diameter from 3.6m up to 4.2m. Such an installation, they believe, would have almost double the capacity of the present kiln without any more labor being required. It might also be added that a properly designed magnetic separation section would considerably improve the yield of iron.

POSSIBLE ADAPTATION TO AMERICAN CONDITIONS

As mentioned earlier, the available Kraluv Dvur data is not detailed enough to permit the development of any very accurate production costs on the process as carried out in Czechoslovakia, but by making certain reasonable assumptions, some interesting figures can be obtained as a basis for further evaluation and discussion of its possibilities under American conditions. In developing our figures we will first estimate what Krupp-Renn metal might cost if the 72 metric ton per day Kraluv Dvur plant were to be operated in this country at a steel works relatively close to a deposit of suitable low grade iron ore.

The cost of relining the kiln between campaigns is estimated first. Later on a cost for putting the high sulfur K-R metal through the blast furnace is developed for comparison with the cost of pig iron made from sintered taconite concentrates. Finally production costs are developed for a 1500-ton per day Krupp-Renn plant to see what might be realized in a large scale American operation on taconite.

Relining — For relining the kiln at the end of a campaign, the information given in the text states that 6000-7000 man hours of labor are required, including 3 shifts of bricklayers of 4 men each for a period of approximately 7 weeks. On the assumption that the total brickwork replaced is equal to a full 13½-in. lining over the lower 20m (66 ft) of the kiln, the quantity involved is equal to 37,000 9-in. brick equivalents. The time of the twelve men of the relining crew at 48 hours per week for 7 weeks amounts to 4000 man hours or 57 per cent of the indicated 7000 man hour total, not counting however the work of half of the operating crew — some 22 men — who according to the text are also busy cleaning up and taking care of minor maintenance work during the relining period. Twenty-two men at 48 hours for 7 weeks is 7400 man-hours. On this basis total relining labor at Kraluv Dvur amounts to:

Bricklaying	4000 man-hours
Other shop and general maintenance labor	3000 man-hours
Total	7000 man-hours
Time of operating labor-kept busy on maintenance during relining period	7400 man-hours
Grand total	14,400 man-hours

Under highly mechanized American conditions, it seems reasonable to expect that the same work might be done with the same number of men in four weeks' time, i.e. 4/7 as much. On this basis the man-hour figure drops to 8300 man-hours, of which the bricklaying in the kiln would probably account for 12 men × 56 × 4 weeks or 2700 man-hours. Taking labor at 15¢ per 9-in. equivalent, this amounts to $2.06 per man-hour for bricklayers and helpers, which is a reasonable figure under U. S. conditions with some overtime included. The remaining 5600 man-hours at the average U. S. steel industry wage rate of $1.70 per hour is equal to $9500. The cost of relining the Kraluv Dvur kiln in the U.S. under these assumptions then is:

37,000 super-duty brick @ $100/M	$ 3,700
Bricklaying — 2700 man-hours @ $2.06/hr	5,500
Other Labor — 5600 man-hours @ $1.70/hr	9,500
Repair parts, maintenance materials and supplies, assumed equal to other labor	9,500
	$28,200

For a 180-day campaign at 72 metric or 80 net tons per day this gives a relining cost of $1.95 per net ton.

Kraluv Dvur under U. S. costs — Relining cost is normally included as an item of operating expense. The balance of the operating or production "cost above raw materials" is now estimated. Taking the same crew as at Kraluv Dvur, or 44 men per day, the labor cost per ton would amount to 44 × 8 × $1.60 per hour = $564 per day or $7.05 per ton of reduced product. Doubling this (for lack of a better assumption) gives a total cost above raw materials and fuel of $14.10 per ton to which must be added the relining charge, bringing the total cost above to $16.05 per net ton.

The total cost of Krupp-Renn iron on the basis of Kraluv Dvur practice and U.S. wage rates and costs, at a hypothetical lower lake port steel works, assuming cheap nearby iron ore might then be:

Iron ore — 28 per cent Fe @ $1.50 per net ton, delivered to nearby steel plant ($5.36/Fe unit)	$ 5.36
0.9-ton coke breeze @ $4.50 per net ton	4.05
0.285-ton pulverized coal @ $7.50 per net ton	2.14
Total raw material and fuel	$11.55
Cost above, as above	16.05
Total cost per net ton of iron granules containing 92 per cent metallic Fe	$27.60

K-R metal blast furnace cost — Krupp-Renn metal is high in sulfur since under acid slag conditions an appreciable part of the sulfur in the coal and coke breeze is absorbed by the metal. It must therefore be put through the blast furnace to desulfurize it. (The results of some interesting laboratory work on the gaseous desulfurization of K-R metal with H_2 and high H_2 gases has been published in Japan.) Assuming a 4:1 melting ratio for the reduced metal and a 3:1 ratio for the 500 lb of blast furnace slag volume required to absorb its 0.60 per cent sulfur content, the total coke required amounts to a third of a ton of coke per ton of pig iron. Blast furnace capacity would be greatly increased compared to normal ore practice due to the fact that the Krupp-Renn product is metal — not ore — as already indicated by the low amount (1/3 ton) of coke required. It therefore seems reasonable to expect that the capacity of a blast furnace on Krupp-Renn metal would be doubled, with a resultant reduction in the cost above of a large multi-furnace plant of $1 per ton. The cost of converting the Kraluv Dvur Krupp-Renn granules (92 per cent Fe) — there will be practically no flue dust loss as the K-R metal contains nothing finer than 20 mesh — to 93 per cent pig iron (neglecting the cost of any manganese required) would then come to:

1/3 ton coke @ $10/net ton	$ 3.33
1/4 ton limestone @ $2	0.50
Net blast furnace cost above	1.50
Conversion cost to molten pig iron	$ 5.33
Cost of K-R granules per net ton	27.60
	$32.93

This figure is probably $7 to $8 higher than the cost of hot metal at most of the multi-furnace plants of the larger integrated companies today. The above $32.93 figure represents simple production cost without any capital or overhead charges.

Pig iron from taconite — A comparative figure for the cost of making pig iron in a blast furnace from agglomerated taconite concentrates, assuming a cost of $8 per net ton — not including any beneficiation plant capital charges — for taconite sinter at lower lake port steel plants is developed below:

1.6 tons of 62.5 per cent Fe taconite sinter @ $8 per net ton	$12.80
0.75 tons coke @ $10 per net ton	7.50
0.6 ton limestone @ $2	1.20
Cost of materials	$21.50
Net blast furnace cost above (after gas and other credits)	2.50
Cost of hot metal	$24.00

(It will be noted from the above that if the capital cost of taconite concentration and sintering plants is neglected, the cost of pig iron from taconite is about the same as that indicated two paragraphs above for pig iron produced under present normal ore practice.)

The difference between the U.S. Kraluv Dvur-plus-blast-furnace hot metal cost of $32.93 and the above taconite figure of $24 is $8.93 per ton. This is so large that it would appear to rule the K-R process out of the picture. However, the production cost figure developed above was for a small, single kiln Krupp-Renn plant with an output of only 80 net tons of product per day; i.e. Kraluv Dvur conditions and U.S. costs. This does not mean that the K-R process could not perhaps be adapted to U.S. conditions on a larger scale with a more favorable result. In order to see what might be done in a large scale Americanized version of Kraluv Dvur still further assumptions will have to be made.

Large scale U.S. K-R costs — Let us accept in the first place the Czech furnaceman's opinion that a larger kiln — 13 ft 0 in. (4.0m) in diameter and 250 ft (76m) long — is feasible, and that given proper conditions such a kiln can operate for 9 months with an average output of 150 net tons of K-R metal product per day. This amounts to a production of 40,500 tons for a 270-day campaign. We further assume that under American conditions the larger kiln can likewise be relined in 4 weeks' time. In the figures below we have also increased the yield from 88½ to 92 per cent with a product grade of 93 per cent Fe, by using better magnetic separator equipment in an improved circuit.

An analysis of the relining cost of this larger kiln, assuming replacement of the lower 80 ft of its brickwork, or 57,000 9-in. equivalent is:

Brickwork 57,000 @ $100/M	$ 5,700
Bricklaying 57,000 @ 15¢/9-in. equivalent	8,550
Other shop and general maintenance @ 5600 man-hours as before @ $1.70/hr	9,500
Repair parts, maintenance materials and supplies (assume 50 per cent greater than before)	14,250
Total	$38,000

For a 40,500-ton campaign, this amounts to a relining cost of 94¢ per net ton.

Other operating costs, particularly for material handling, will naturally be considerably reduced due to the larger output from a multi-kiln plant. An analysis of Kraluv Dvur's required labor force indicates that in a properly designed large scale plant — taking for example one having 10 kilns in a row capable of producing 1500 tons of Krupp-Renn granules per day — an operating force of no more than 25 men per kiln per day should be required on the average.

Assumptions made — In working up the production costs given in Table XII, it is assumed that —0.2 in. crushed taconite can be delivered to such a Krupp-Renn plant located close to a taconite deposit in Minnesota for 90¢ per net ton; that coal or an equivalent fuel is available at 33¢ per million Btu ($9/ton for 13,600 Btu/lb) and that North Dakota lignite char as a reducing agent will cost $8.50 per net ton. A 30 per cent Fe, 50 per cent SiO_2 taconite will have a Krupp-Renn slag volume ratio of about 2.1 compared to 1.7 at Kraluv Dvur, it might be even higher if it were found that a little limestone was required. Because of this a slightly higher fuel consumption is taken, though the longer

TABLE XII

Cost of Producing Krupp-Renn Metal from Taconite

	Per Net Ton Krupp-Renn Metal	
Raw materials and fuels		
3.36 tons crushed —0.2 in. 30 per cent Fe taconite @ 90¢/net ton	$ 3.02	
Fuel: 1/3 ton coal for pulverized fuel firing @ $9/net ton	3.00	
1600 lb reducing agent (lignite char) @ $8.50/net ton	6.80	
Total materials and fuels	$12.82	$12.82
Cost above materials and fuels		
Labor — direct — 25 men x 8 hr x $1.65 ÷ 150 =	$ 2.20	
Repairs and maintenance (at ½ relining cost)	0.47	
Supplies and miscellaneous @ $50/kiln/day	0.33	
Plant service — switching, labs, etc.	0.65	
Relining reserve (as developed in text)	0.94	
Disposal of waste slag — 2.1 tons/ton of product @ 25¢/ton	0.52	
Total	$ 5.11	
General works expense	0.50	
Total cost above	$ 5.61	$ 5.61
Total cost of 93 per cent Fe Krupp-Renn metal f.o.b. taconite mine site, Minn.		$18.43
RR — Mesabi to Duluth (at Jan. 1949 ore rates)	1.05	
Lake freight to lower lake ports	1.44	
Total delivery charges		2.49
Total cost delivered lower lake blast furnace plants		$20.92
Add conversion cost to molten pig iron — as per text		5.33
Cost of hot metal from taconite via Krupp-Renn process		$26.25
Previously arrived at cost of hot metal from agglomerated taconite concentrate		$24.00
Difference in favor of agglomerated taconite concentrate		$ 2.25 per net ton of pig iron

larger kilns should increase heat recovery efficiency.

Capital cost — The above production cost figures do not tell the whole story, however, as capital costs have not been considered. The capital cost in the U.S. of a 10-kiln, 1500-ton per day Krupp-Renn plant has not been estimated accurately, but it should be possible to put up such a plant — if not the first one, then subsequent ones — for approximately eight million dollars.

Eight million dollars — at 90 per cent kiln availability — is equal to an investment cost of about $16 per ton of annual capacity. This is about the same order of magnitude as the $15-$20 per annual ton of concentrate capacity commonly quoted as the investment needed for the combined magnetic taconite concentration, plus agglomeration plants currently under development. Such plants however supply only a 60-65 per cent Fe unreduced product, compared with the 93 per cent of reduced metallic Fe produced by a Krupp-Renn plant. *Per ton of Fe* therefore our assumed Krupp-Renn plant would cost only $17.20 compared to $25.60 for a taconite concentration and agglomeration plant, a difference of $8.40 in favor of the former.

While taconite sinter or other agglomerate can be expected to increase blast furnace output by perhaps as much as 20 per cent compared to ordinary ore because of lower coke consumption (1500 lb per ton vs 1800) the substitution of Krupp-Renn metal for taconite sinter would permit a much greater increase — theoretically in inverse ratio to the coke rate. This should not be taken to mean that it would be either technically feasible to use only K-R metal on a blast furnace without any ore at all, or if 100 per cent of it were ever actually so used, that the furnace would produce 3.6 (1800:500 lb of coke) times its normal output. Nevertheless it does not seem wholly unreasonable to assume that the use of Krupp-Renn metal would proportionately double blast furnace capacity. This would reduce the required investment in coke ovens and blast furnaces from perhaps $25,000,000 for a capacity of 1500 tons of pig iron per day, or $46 per annual ton, down to half as much or $23. This saving of $23 in blast furnace and coke plant investment plus the $8 difference at the mine, amounts to a total saving in investment cost of $31 per annual ton of pig iron or a total saving in capital cost of more than $16,000,000; i.e. compared to a new 1500-ton blast furnace and coke plant backed by taconite concentration capacity. The saving of fixed charges on this at 10 per cent, or $3.10 per ton, is larger than the $2.25 difference in production cost previously estimated in Table XII.

It would obviously be foolish to place too much reliance on figures, estimates and calculations of the sort just presented above; they are based on far too many suppositions and far too few actual facts. Nevertheless, they do suggest that the Krupp-Renn process may not be so entirely non-competitive with other ore beneficiation methods as has been commonly supposed. If actual trials should show that the process as it is now actually functioning in Czechoslovakia can be successfully transferred and used on raw taconite in this country, the cost assumptions made above are believed, if anything, to be on the conservative side. In addition, there is a tremendous tonnage of low-grade ore amenable to the process containing between 35 and 40 per cent Fe which should result in lower costs than those estimated for 30 per cent Fe taconite.

Recovery of iron from Fe silicates — There is one other important consideration in favor of the Krupp-Renn process, and that is that it, like the blast furnace, acts on all the iron in the ore, including that in the form of silicates or other complex minerals which cannot be recovered by magnetic separation, either with or without a magnetic roast. In the case of magnetic taconites containing 32 per cent total iron, usually only about 25 per cent of the Fe is in the form of magnetite. A 95 per cent recovery of the magnetic Fe present in the taconite therefore represents a recovery of only 75 per cent of its *total* Fe content, compared to 92 per cent recovery for a Krupp-Renn plant. This means that 0.8 of a ton more taconite must be mined and processed for each ton of Fe shipped to the blast furnaces in the case of the present conventional process as compared to the Krupp-Renn. The fact that the Krupp-Renn process can be used regardless of the form in which the iron occurs in the ore — always provided the gangue is

sileceous and acid enough — is probably one of the most important and fundamental advantages that it has.

Summary — From the results of the Kraluv Dvur tests and the above brief discussion, the main advantages of the Krupp-Renn process may be summarized as follows:

1. It makes possible the recovery of iron present in the form of silicates in the ore which cannot be recovered by any other ore beneficiation process.
2. It can be used to process non-magnetic taconites directly without magnetic roasting.
3. It would increase the iron carrying capacity of the Lake ore fleet since less gangue and oxygen would be carried from Minnesota to the blast furnace plants.
4. While showing no saving in total fuel requirements, it would save blast furnace metallurgical coke (1/3 ton vs. ¾ of a ton).
5. The use of Krupp-Renn metal would greatly increase the capacity of any given blast furnace.

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U. S. STEEL INITIATES ALL-RAIL ORE SHIPMENTS

▲ U. S. Steel Company plans to ship 2,000,000 tons of ore this winter from the Mesabi range to plants in Chicago, Ill., Gary, Ind., Pittsburgh, Pa., and Youngstown, Ohio. The company expects to receive 500,000 tons in the Chicago district, 500,000 tons at Youngstown, and 1,000,000 tons at Pittsburgh.

It is the first time ore has been shipped on a large scale by rail in winter. Normally the ore is moved by boat during the Great Lakes navigation season with stockpiles carrying the mills over the winter months.

For the Pittsburgh district, U. S. Steel Co. is setting up a thawing station in the Peterson Yards between Oak Hill and North Bessemer. Three one-fourth mile tracks in the yard have been set aside, the outside two tracks will have a capacity of 35 cars each, and the inside track will be used to accommodate steam lines. Three-in. lines are tapped to the main 6-in. lines every 30 ft, and 8 steam jets, four on each side are inserted in each car for thawing. Four locomotives are used for steam supply.

Figure 1 — Workman inserts steam jet into side of railroad car to thaw out first shipment of frozen iron ore. The steam passes through a length of perforated steel pipe, which is inserted in holes in the ore cars.

At Gary, the thawing is being done inside the company's gates.

Because U. S. Steel mills at South Chicago lack space for thawing the ore, the cars are placed on a siding at 101st Street and the Calumet River. Four old locomotives leased to U. S. Steel by the Burlington Railroad provide the steam to warm the tightly frozen ore. The thawing process consists of piercing a load of ore with a steel jet and applying steam. After the ore is thawed, it is placed on a barge and taken down the river to the South Chicago works.

Prior to shipment by the Oliver Iron Mining Company, the ore was treated at the mines with calcium chloride to retard freezing.

U. S. Steel plans to continue regular shipments from the mines until March 15. The Great Lakes usually open for navigation in April.

Illustrations are for Chicago district installation.

Figure 2 — Men use long plungers to tamp ore onto conveyor after dumping. Although the ore was loaded at 20 degrees below zero and temperatures in Chicago were below freezing, the thawing out process was successful for the first shipment.

ROLLER GUIDES IN MODERN MERCHANT MILL PRACTICE

By C. S. LAMBERT
Superintendent of Merchant Mills
The Youngstown Sheet and Tube Co.
Youngstown, Ohio

. . . . roller guides are economical on many mills because they help to produce better yield and better product . . . .

▲ MAN'S progress in acquiring the knowledge considered to be basic in our civilization is chronicled by events such as the discovery of the art of working metals and the invention of the wheel. The wheel, applied as a mechanical element to machines, was known in ancient civilizations. In historical writing it is referred to as a criteria for determining the level of civilization of a people. The concept of devices which we call rollers is an ancient one. A roller can be considered a higher development of the primitive wheel to the extent of qualitative refinements.

With respect to modern day industrial equipment the probability of a novel application of rollers would seem remote. Nevertheless, the development of the use of rollers in guide equipment has been comparatively recent. The reason for this is not entirely due to the fact that human ingenuity has lagged. Rather, the successful development of this production tool required materials that would insure a reasonable life under the destructive action of heat, pressure, scale and water. The advent of hard cast alloys, carbides, tool steels, water-lubricated phenolic bearings, high efficiency anti-friction bearings and superior metallic bearings has made the application of rollers to rolling mill guides feasible in many cases.

It would have been virtually impossible to do with rollers in 1900, for example, what is done today. The short life expectancy of materials then available would have condemned ideas involving the use of rollers as impractical.

Dealing for the moment with generalities, the advantages of substituting rolling contact for sliding contact are:

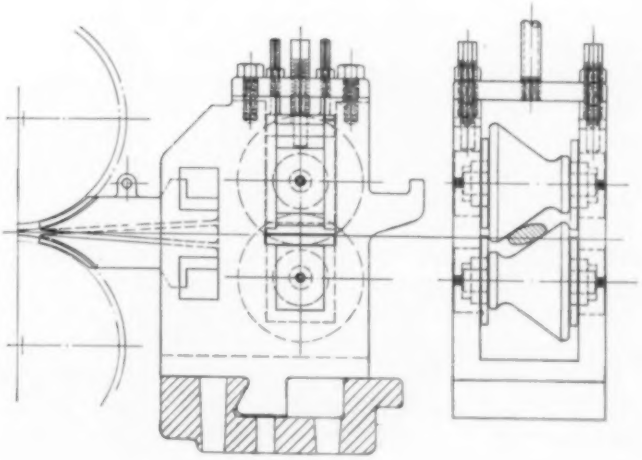
1. Sliding friction is replaced by rolling friction.
2. Wearing surfaces have negligible relative motion with contacting surfaces.
3. Wearing surfaces (rollers) can be replaced or reconditioned without difficulty.
4. The revolutions of rollers afford a means for directing a cooling water stream in such a manner as to impinge on roller surfaces immediately after contact with hot bars.

These are the purely mechanical advantages without consideration of secondary benefits.

APPLICATIONS

The substitution of roller twist guides for friction guides has remedied serious surface quality difficulties, particularly in the case of special requirement steels. When bars, comparatively large in cross-section, are to be twisted in short distances, for example, in bar mill continuous roughing train, the turning couple may be too large for a friction twist guide to produce without heavy shearing. Roller guides are to be recommended wherever a high torque twist, free of shearing, is required. Surface defects on finished material traced to heavy guide shearing has been encountered by almost all merchant mill operators.

Figure 1 — This roller guide is used as a twist guide between two stands of a merchant mill.



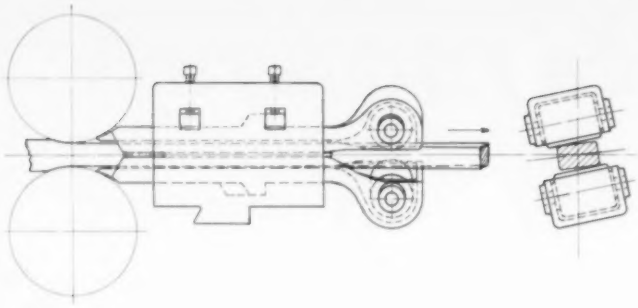


Figure 2 — Roller twist guide shown is used on a 10-in. continuous bar mill.

Figure 1 illustrates a guide used between No. 3 stand and No. 4 stand of a 2-in. merchant mill. The distance between center lines of stands is 3 ft-10 in. The bar twisted is a 2⅜ x 1⅛-in. oval reduced from a 1⅞-in. billet and is to be entered into a square pass.

Figure 2 shows a guide used between No. 1 stand and No. 2 stand of a 10-in. continuous bar mill. The distance between center lines of stands is 13 ft-0 in. The maximum bar size twisted is a 5 x 2½-in. flat reduced from a 4 x 4-in. billet. When rolling large billets, a 7 degree tilted roll pass is used in No. 1 stand in conjunction with the guide. The mill in question is equipped with similar twist guides throughout.

Figure 3 is a sketch of a roller twist guide located between No. 9 stand and No. 10 stand of a 9-in. merchant mill used with a horseshoe repeater. Ovals, diamonds and hexagon leaders are turned up into the repeater for looping into No. 10 stand. In this application the roller twist guide takes the place of a conventional twist delivery guide. The angular pitch of the rollers is variable, making for excellent control of twist. Cobbles in the repeater are infrequent. Scratching or marking of the bar at this position in the mill is no longer a problem. Very little contact pressure by the rollers on the bar is required to produce the desired degree of twist. Location of the guide in relation to the repeater is shown by Figure 4. This has been one of the most successful guide devices of this type.

A type of roller guide used between No. 4 and No. 5 stands in the roughing train of a 12-in. bar mill is shown by Figure 5. The function of this guide is to turn down a flat edged in No. 4 stand for a flat draft in No. 5 stand. The guide housings are affixed to the rest bar of No. 4 stand. The distance between stands is 6 ft-0 in. It is interesting to compare this guide with guides shown in Figure 1 and Figure 2.

The twist guide illustrated by Figure 6 is used on the delivery side of No. 7 stand and the finishing stand of a 12-in. cross country bar mill for the purpose of counteracting twisting produced in the rolls. Its principal application is to unsymmetrical shapes. Figure 6 shows how a special section is controlled by the rollers. The pitch of the rollers is variable throughout 180 degrees.

It has been found advantageous to apply rollers as anti-friction surfaces in entry side guards, delivery side guards, table side guards and table sweeps. A number of such pieces of equipment is referred to concisely by illustrations.

Figure 7 is a roller entry guide for a 9-in. merchant mill. Rollers are adjustable by means of an eccentric pin.

Figure 8 is a roller entry guide for a 9-in. merchant mill with adjustable side guards used on No. 2 stand.

Figure 9 is a roller delivery side guard for a 9-in. merchant mill.

Figure 10 shows a lead trough roller guide used between No. 1 stand and No. 2 stand in the roughing train of a 12-in. merchant mill.

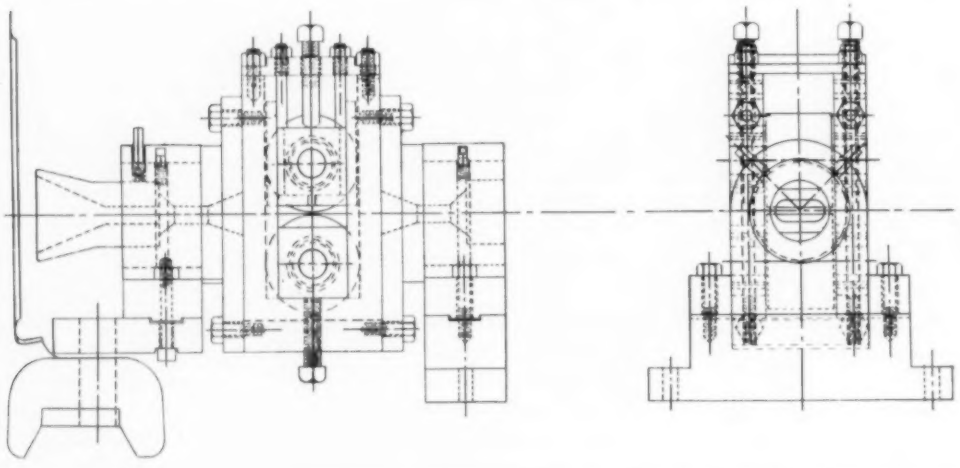
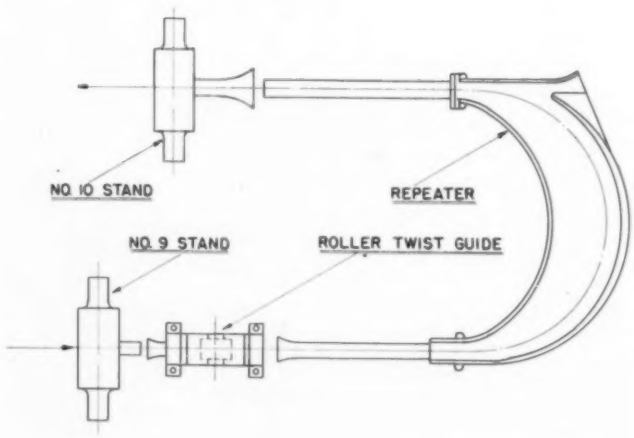


Figure 3 — The roller twist guide illustrated takes the place of a conventional twist delivery guide on a 9-in. merchant mill.

Figure 4 — This sketch shows the location of the twist guide detailed in Figure 3.



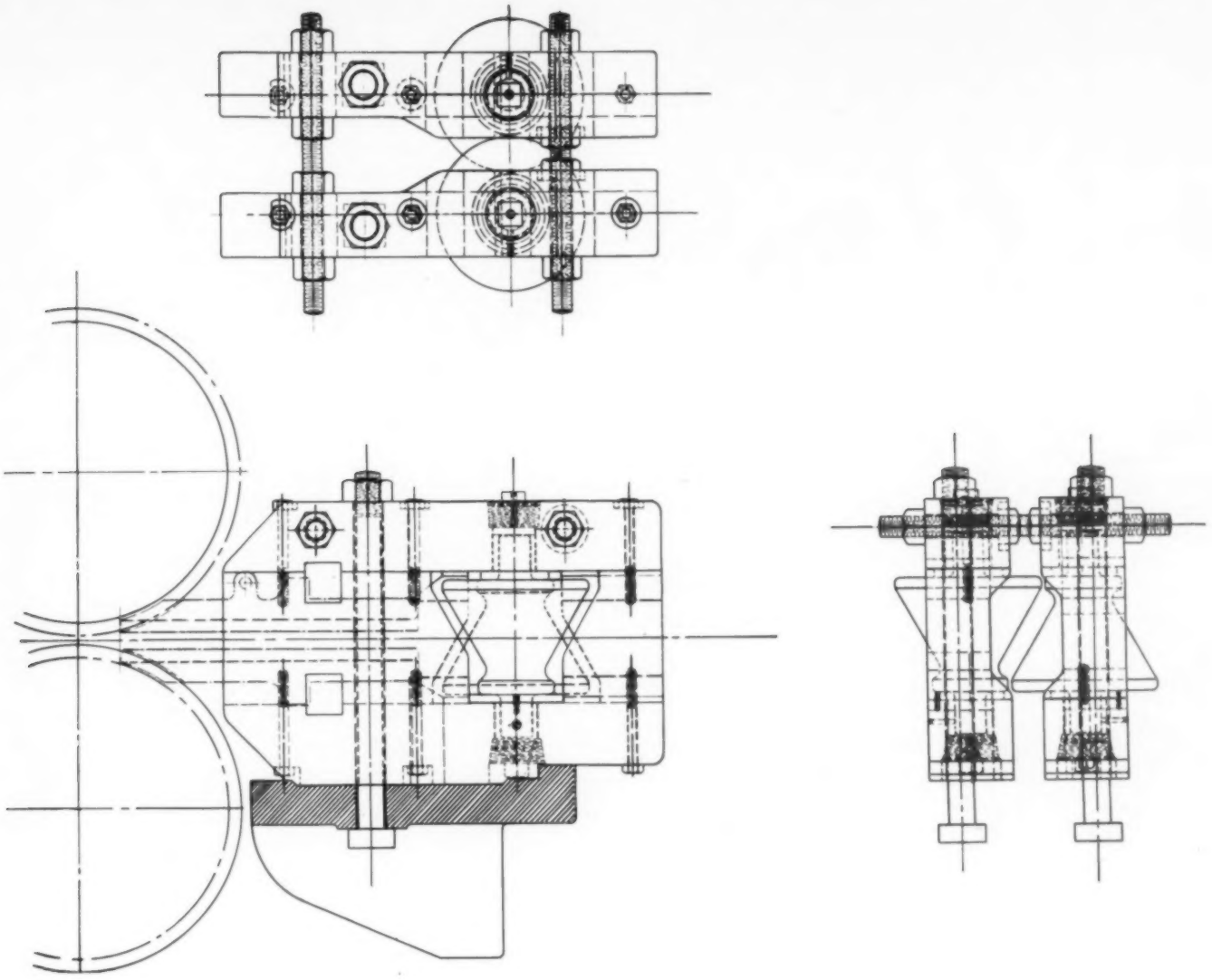


Figure 5 — Roller guide shown is used in the roughing train of a 12-in. bar mill.

Related to twist guides are the so-called "Roller Detwisters." These are used on the delivery side of a stand in order to rectify twisting originating in the rolls. In most cases only a very slight counter torque is required in order to produce a good delivery. With this equipment it is possible to start an order of squares without delay due to troublesome delivery of twisted bars to the hot bed. The detwister is placed immediately following the finishing stand. The appearance of detwisters is very similar to twisters. Figure 11 illustrates a type in use on a 10-in. merchant mill. It will be recalled that the roller guide shown in Figure 6, previously referred to, falls in this category.

The potential of the extent of the use of rollers in guide equipment is limited only by practical considerations and justified on the basis of increased produc-

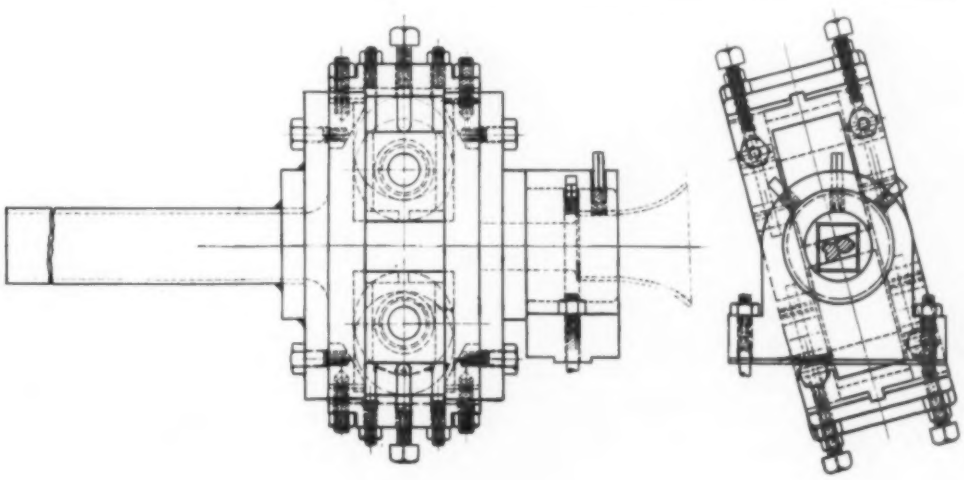


Figure 6 — This roller guide is used as a detwister.

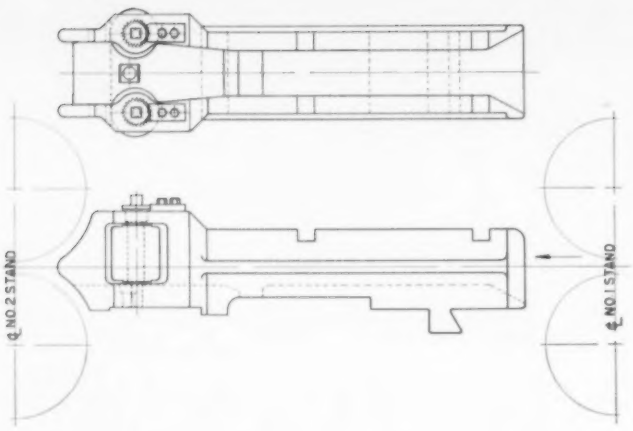


Figure 7 — Roller entry guide for rougher train of 9-in. merchant mill.

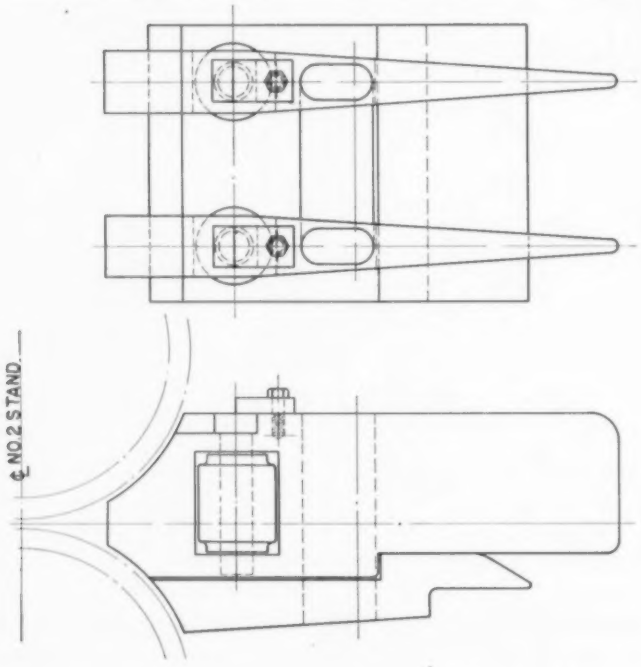
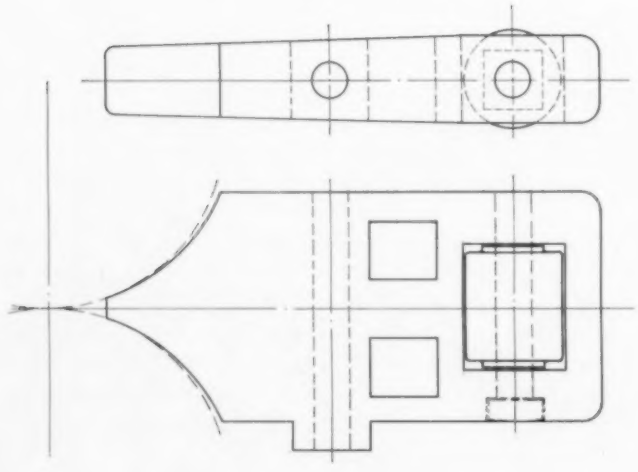


Figure 8 — This roller entry guide has adjustable side guards.

Figure 9 — Roller delivery side guard.



tion, improved quality and savings. Repeaters and twist troughs have been built with multiple rollers spaced regularly along the guided path. Figure 12 shows a large repeater designed for wide flats.

The ingenious repeater as shown by Figure 13 was a solution to the problem of looping narrow strip where stands are too close to permit the use of horseshoe repeaters. The lower roller of the pair of pinch rollers is driven.

The most important development in roller guides has been the adoption of roller entry guides throughout a large portion of the industry for the rolling of rounds and hexagons. In the rolling of guide rounds it has always been the function of the entry guides to lead the bar to the pass and to hold the oval leader with the major axis vertical. Whether the guides are roller or friction guides, this is accomplished by providing a means for moving one guide element so as to provide clearance for the bar to enter between the guides. Thereupon the guides are brought together with pressure bearing on the bar. The guide boxes that operate in this manner are known to the industry as screw or wedge boxes, depending on the construction. It does not take much imagination to picture the trouble experienced with friction guides in this service. Scratches caused by worn guides, hard spots and pick-up result in innumerable delays for guide grinding and changing. The substitution of roller entry guides for friction guides eliminates the evils attending the use of friction guides. The smallest oval for a round that can be held up by roller guides is approximately a $\frac{3}{8}$-in. round. For smaller rounds the point of support on the roller may be too far from the pass, permitting the bar to turn down. However, by making the last supporting rollers very small it is possible to work closer to the centerline of the rolls and hold ovals for rounds as small as $\frac{1}{4}$-in. In the case of larger rounds the roller size may become so large that the cumbersome guide box assembly may preclude use of a major part of the available roll body for passes. In general, roller guide boxes cause passes close to the end of the roll to be abandoned or the rolls to be redesigned. In order to improve this situation left hand and right hand boxes are used when working end passes.

Figure 14 illustrates an assembly of rollers and guide frames mounted in a guide box ready for use. This type of guide box is adjustable by the rack and pinion wedge mechanism but is not operated from open to shut positions while rolling. The 12-in. bar mill where this box is used is suitable for a fixed guide box arrangement because the undistorted back end of the bar delivered from the leader is entered into the finishing pass by a tongsman with the assistance of a conveyor table.

Another variety of roller assembly and guide box is shown in Figure 15. This is a rack and pinion wedge type box operated from open to closed position manually. It is in service on a 10-in. continuous bar mill operating at speeds up to 2400 fpm on small rounds. Because of the high speed and distorted front ends produced by rolling continuously in the same direction, it would be impossible to enter bars into fixed guides without repeated cobbles.

A guide box set up for rolling hexagons is pictured in Figure 16. This is the same guide box shown in Fig-

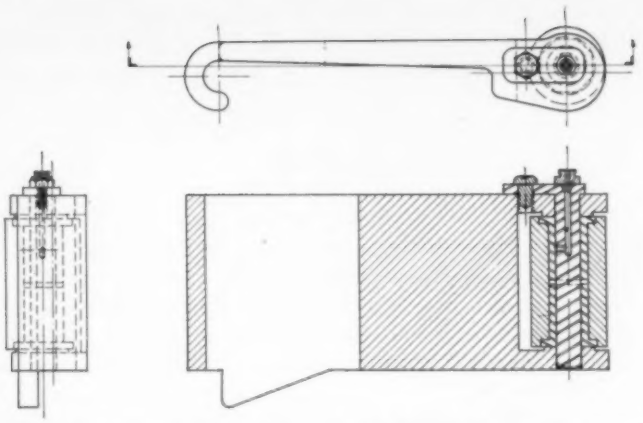


Figure 10 — Lead trough roller side guard for 12-in. merchant mill.

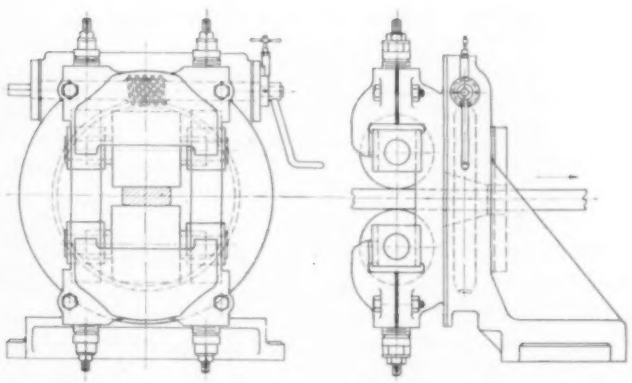
ure 14. Roller entry boxes may be used for special sections resembling rounds in rolling method. Some operators even use roller entry guides for holding flats on the finishing pass when no side movement in the pass is desired.

OPERATING ART

In the foregoing an examination of the broader aspects of the subject quickly disposed of questions that will now be examined closely from an operating standpoint, particularly with respect to roller entry guides.

Control of quality must be vigilant without penalizing production. When a proposition offers improved quality as well as increased production, it cannot be ignored. For example, low carbon resulphurized open hearth, commonly called screw stock, has surface characteristics particularly difficult to cope with because of adhesion of the bar surface to guides. Roller guides have helped overcome this problem to the extent of doing away with the scratching and delays for changing and grinding guides. In addition, yield has been increased by eliminating cobbles and rejections due to surface defects. Further savings are realized by a reduction in reconditioning costs.

Figure 11 — The roller twister illustrated is in use on a 10-in. merchant mill.



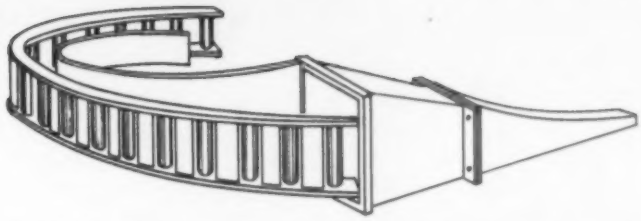


Figure 12 — This repeater for flat products is equipped with rollers.

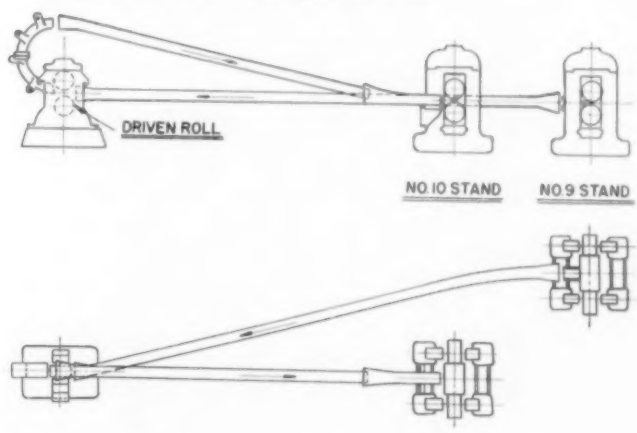
By rolling rounds with roller entry guides, it is possible to hold size to close tolerances because of a precise guide setup. This precision, however, must extend to the setting of the rest bar and the rolls. The rest bar must be level, the rolls plumb and passes aligned. Otherwise, difficulty may be encountered in holding size for an extended period. Roller bearing outboard thrust bearings are a valuable adjunct and make a perfect teammate for roller guides. Under these conditions the dimensions of a round should not vary from the effects of leaning ovals or crossed rolls. The initial setting of the rollers of the guide shown by Figure 14 is made snug, with a set bar $\frac{1}{32}$-in. larger than the size round to be rolled. If necessary, the guide is pulled in slightly by means of the rack wedge. It is essential that the two guide frames are parallel so that all rollers rotate on contact with the bar. It should be recalled that this particular box is used in a fixed position only.

High pressure water directed toward the rollers by orifices opposite the rollers result in effective cooling, reduction in fire checking and longer roller life. In addition, the high velocity water washes away scale that would otherwise accumulate on the rollers and carry through the rolls. Figure 17 shows an arrangement of a cooling system incorporated in a guide frame.

Some phenomenal tonnages have been obtained on rollers. As a matter of interest, Table I indicates tonnages obtained on various rollers.

When rolling a schedule of rounds it has been found good practice to start with small sizes changing to larger sizes. By this procedure, the wear on the roller groove does not mark the bar. The movement of the contact point is away from the previous wear point. However, this is not necessary on high production mills rolling large tonnages of the same size rounds. Roller

Figure 13 — This repeater is used for looping narrow strip when stands are close together.



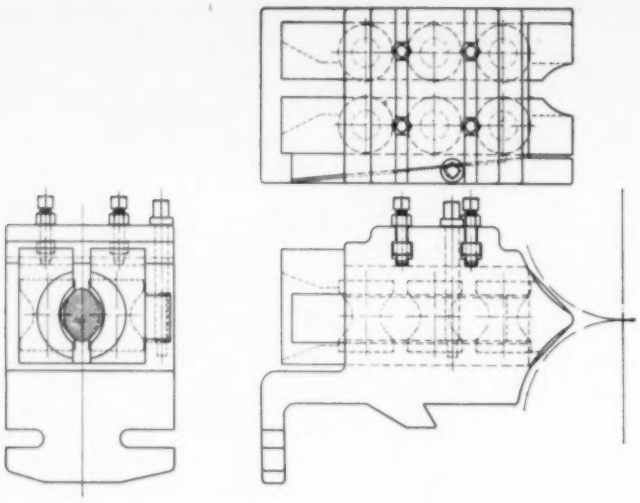


Figure 14 — Adjustable roller guide box.

as well as bearing life is increased by a shot of light graphitic grease every two operating hours through grease fittings provided for this purpose. A bearing frozen due to lack of lubrication will soon cause destruction of the roller.

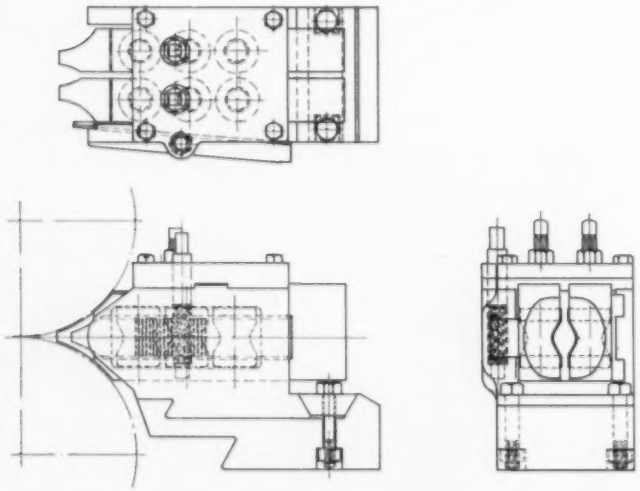
TABLE I

12-IN. MERCHANT MILL

Roller mark	Range of round Sizes — In., Incl	Average tons per dressing
A	$2\frac{1}{8}$—$2\frac{9}{16}$	8000
B	$1\frac{5}{8}$—$2\frac{1}{16}$	8000
C	$1\frac{1}{4}$—$1\frac{9}{16}$	6000
D	$\frac{9}{16}$—$1\frac{3}{16}$	2000

It is possible that slivers may become trapped behind rollers and cause the roller to freeze. In that event, the guide frame is quickly changed. A stationary roller, however, is hard to detect. The first indication may show up on bars delivered to the hot bed.

Figure 15 — Rack and pinion wedge type guide box.



Breakage of roller pins is rare but occurs occasionally due to the impact of hooked ends on bars. This trouble can be eliminated by rectifying the cause of the hooks.

DESIGN

Although many of the ideas and improvements pertaining to guides originate among mill personnel, the development of these ideas must be worked out on a drawing board. The guide designer takes it upon himself to correlate suggestions and requirements to the physical dimensions and conditions of the mill.

In the design of roller twist guides, the angular pitch of the rollers must be calculated to produce the desired

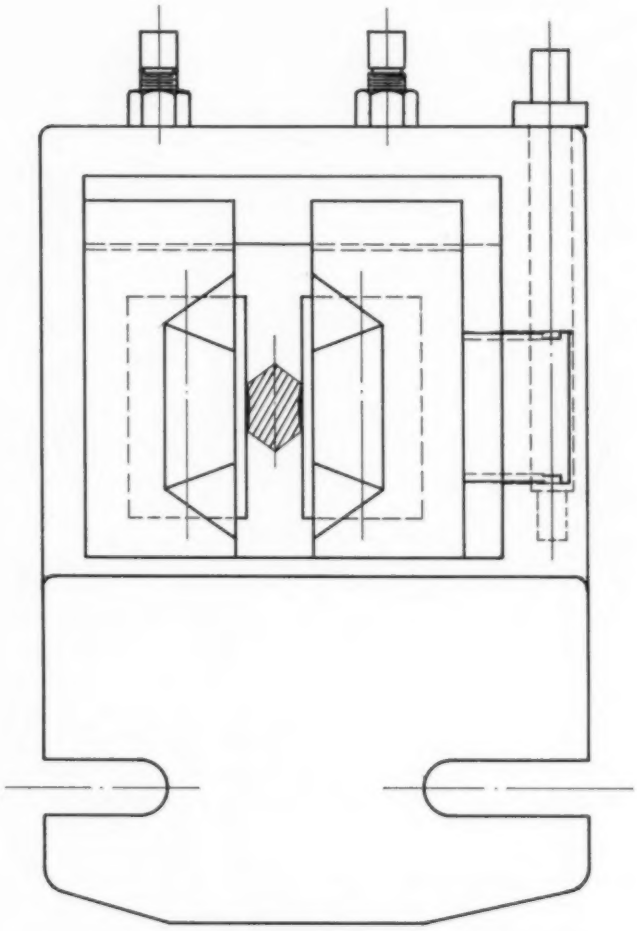


Figure 16 — This roller guide is used for hexagons.

degree of twist. The angular displacement, theoretically, is easily reduced to units of degrees per foot. Thus, the angle of twist obtained between the rolls and guide will be reproduced proportionately on delivery from the guide rollers. However, in actual practice it has been found better to exceed the theoretical angle slightly. Thus, an opening and closing movement of the rollers may be used to control the twist beyond and short of the theoretical angle. The adjustment available permits compensation for variables such as temperature, grade of steel and shape of section. The guides shown in Figure 1, Figure 2, Figure 5 and Figure 6 are adjustable by opening and closing of the rollers. The guide shown in Figure 1 is equipped with adjust-

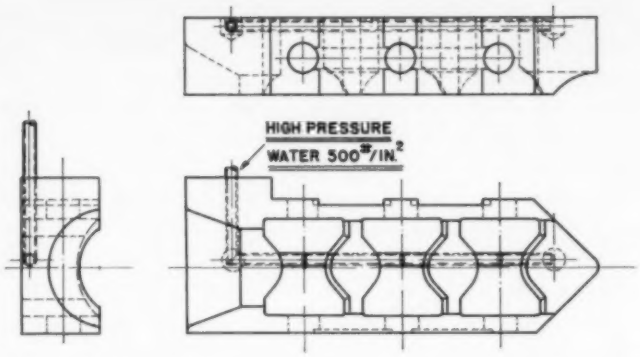


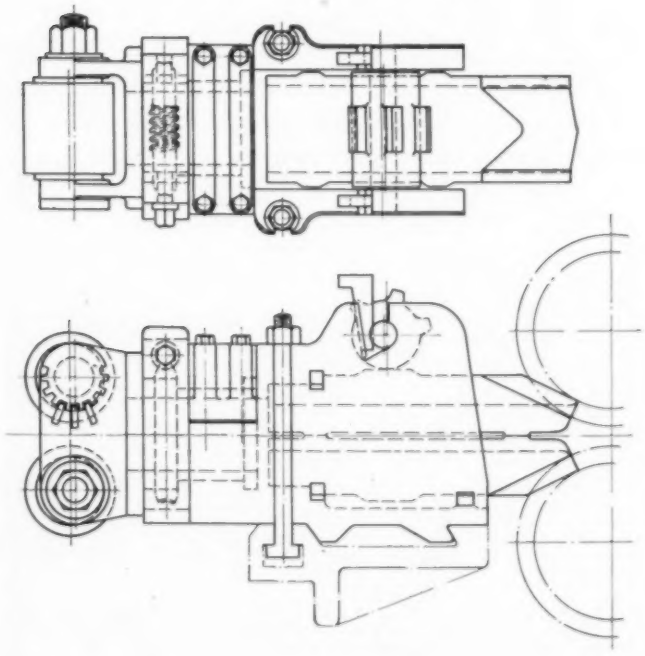
Figure 17 — Sketch shows arrangement of water tube on guide frame.

ing screws, whereas the guide shown in Figure 2, by contrast, accomplishes adjustment by means of liners and set screws. The guide shown in Figure 3 is provided with both roller spacing adjustment and angular adjustment by means of revolving the whole housing in trunnions and locking with set screws. It is necessary to provide short friction guides from rolls to roller twister in most instances. The function of the short guides is to enter the front end of the bar. Thereafter, the twist produced by the rollers exceeds the twist in the friction guides and no bearing is upon the friction guides. The design of Figure 2 incorporates twist rollers and friction guides in one assembly.

A rather effective means for roller guide angular adjustment is a worm wheel and gear. Figure 18 illustrates a guide of this type. The convenience of this type of equipment, however, can conditionally be dispensed with by provision of simpler mechanism.

The type of bearings selected for a roller twist guide depends on the size that can be housed. If enough space is available, anti-friction bearings are preferable.

Figure 18 — The roller pitch on this roller twist guide is adjustable by means of a worm and gear.



However, if space is limited, laminated phenolic or metallic bearings may perform satisfactorily.

It should be observed in the design of these twisters that there are two types with respect to the contour of the rollers, cylindrical and shaped. It follows that there is a choice between cylindrical rollers with skewed axes or skewed passes in the rollers with rectangular axes. The selection of type depends on such circumstances as space limitations and strength of construction. Simplicity in the roller shape results in complication of housing design and vice versa. The individual solution is a design problem.

The size and mass of the rollers in a twist guide should not be out of proportion to the bar to be twisted. Otherwise, the friction of the bar will not be sufficient to accelerate the rollers. Inertia of rollers can be reduced by coring out the roller casting as illustrated by Figure 19 A or by an antifriction bearing mounting inside of a hollow roller as shown by Figure 19 B.

The roller cast with an integral shaft removes the

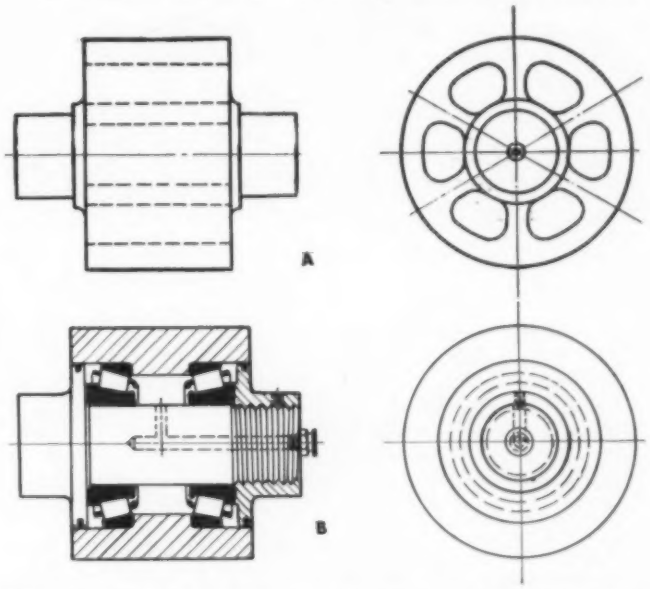


Figure 19 — In "A" above is shown a cast twister roller, and in "B" below is shown a roller for a twist guide inside mounted bearings.

bearings from the heat zone. An inside bearing mounting requires water cooling of the roller body and has the advantage of affording a means of lubrication while operating.

The design of the groove in the rollers of entry guides for rounds is dependent on the type of oval to be supported. Tangent points should be well out on the shoulder of the oval for stability. Figure 20 shows the maximum and minimum conditions for the size range of two pairs of rollers. Note that the limiting conditions are determined by a minimum parting for the smallest oval and by the tangent point on the shoulder for the largest oval.

The subtended angles of the grooves vary from 100 to 120 degrees. There is variation in these angles from mill to mill depending on the design of the leader oval and the range of sizes to be covered. It is characteristic for fast continuous bar mills to use thin ovals compared to blunt thick ovals on slower cross country or looping mills. In selecting these angles the object of maintain-

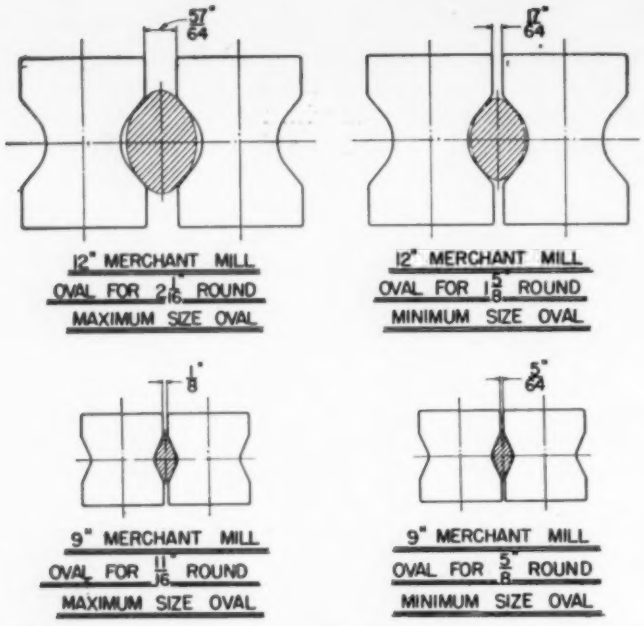


Figure 20 — The maximum and minimum conditions for the size range of two pairs of rollers are shown in this figure.

ing tangency near to the edges of the oval is foremost. Figure 21 illustrates rollers and oval leaders for a continuous bar mill. The same sizes are shown in Figure 22 for a cross country bar mill. Occasionally special grooved rollers are demanded for sections similar to rounds. The ordnance section shown by Figure 23 gave considerable trouble until roller guides were used.

The groove in a roller may be responsible for a weakening of the casting at the bearing race or throat position. Elimination of the roller bearing outer race and taper grinding the bore of a roller to act as the outer race substantially increases the strength. Figure 24 shows a weak roller (A) compared to an integral outer race roller (B). When fracture occurs in a roller of type (A), it usually starts at the bearing race. Breakage at the throat position can be minimized by increasing the fillet radius.

Ball or roller anti-friction bearings are essential to the successful operation of roller entry guides. Life for either type is about the same. The tapered roller type offers the advantage of using the guide roller as an outer race. Ball bearings, on the other hand, are available from many suppliers in the same size. This is an advantage in times of national emergency. Dirt seals and a method of lubrication promote bearing life. Figure 25 shows three methods of bearing mounting in cross section.

MATERIALS

In reviewing the situation with respect to materials, it must be admitted that it is difficult to specify the correct material in the first place in every case. Many times exploratory trials must be made. The best performing material is not always used. For instance, our

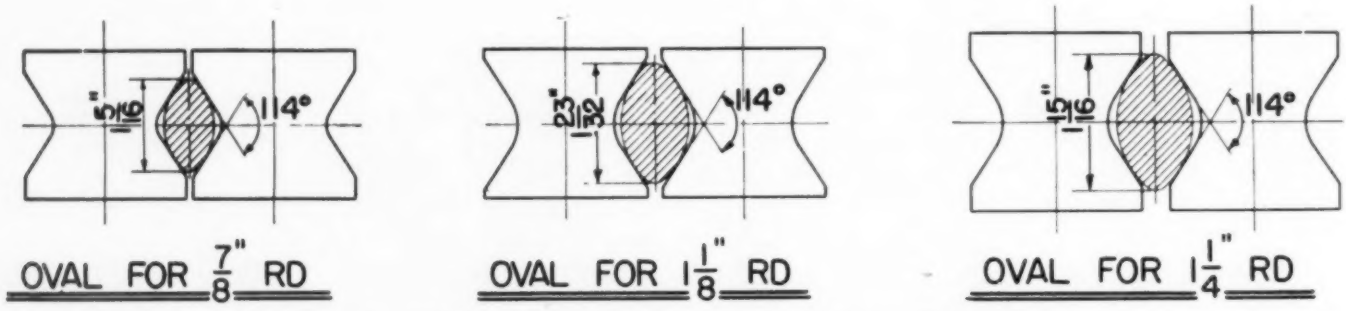


Figure 21 — Rollers and oval leaders for 10-in. continuous bar mill.

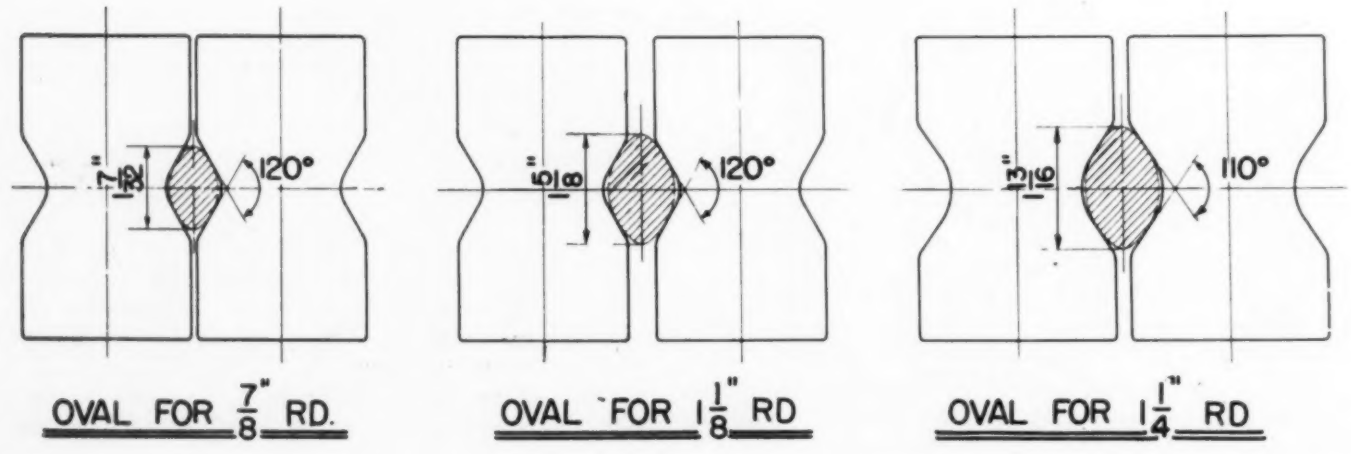


Figure 22 — Rollers and oval leaders for a 12-in. crosscountry mill.

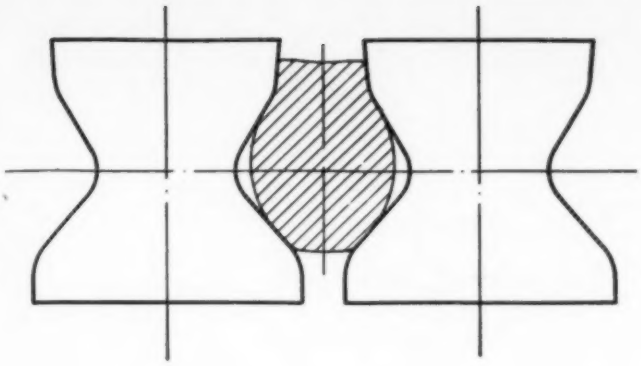


Figure 23 — The use of special rollers for this ordnance section eliminated a number of production troubles.

preference is cast steel for twister housings because of the inherent rigidity and freedom from warp. Nevertheless, we use welded fabricated steel construction because of the savings in patterns and the availability of flat rolled steel. The maintenance cost of this construction has not been high.

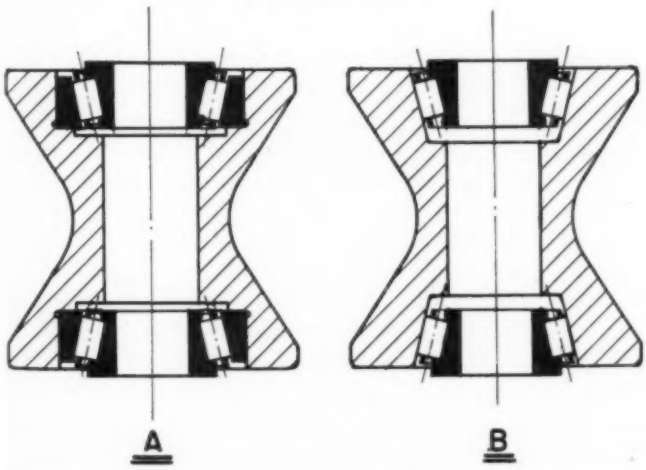
Cast alloys are used for twister rollers as well as entry guide rollers. Originally, hardened forged alloy steel was tried for roller bodies. However, it was found that temperature conditions were too severe. Either the hardness decreased because of the drawing effect of elevated temperature or fire checking was produced by alternate heating and cooling. Cast alloys presently in use have wearing qualities not entirely a function of superficial hardness. As cast, they are on the borderline of machinability. Carbide cutting tools are used for original turning and boring. Alloys deposited by arc welding on a carbon steel base are used in some plants. The welding operation requires skill in order to avoid blow holes. One hole makes a roller unfit for use. We conclude that the risk is too great in comparison to the savings involved.

MAINTENANCE

Roller guide equipment, by nature of its more delicate mechanical design, must have the attention of a skilled mechanic. Careless procedures will not do. Good housekeeping and careful maintenance work is the only insurance for dependable, delay free operation. It is customary to assign a member of the mill crew to a position of "Guide Man." In this capacity, he maintains the guide equipment of one or more mills. In some instances he is the supervisor of a guide shop. Otherwise, he expedites his work through the machine and roll shops.

We have found that the dressing of cast alloy rollers is accomplished to the best advantage by plunge grinding in a small universal grinding machine. In this respect we are fortunate in having a roll shop with this equipment.

Figure 24 — On the left is shown a bearing mounting using a cup and cone, and on the right is shown a bearing mounting using a cone only.



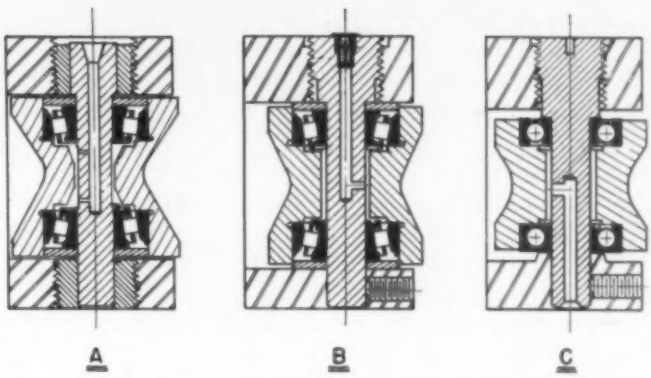


Figure 25 — Sketch shows three methods of mounting bearings.

CONCLUSION

The writer is well aware that other organizations have developed successful practices with regard to roller guides which could richly supplement the thoughts expressed in this paper. He had drawn on his own experience for much of the material. Conditions in other mills may require practice at variance with these ideas. Without doubt, there is much to be said and done on this subject.

DISCUSSION

PRESENTED BY

LOUIS MOSES, Superintendent, Rail Mill and Roll Department, Bethlehem Steel Co., Sparrows Point, Md.
and
MARTIN L. WEIKERT, Assistant Superintendent, Rail Mill and Roll Department, Bethlehem Steel Co., Sparrows Point, Md.
C. S. LAMBERT, Superintendent of Merchant Mills, The Youngstown Sheet and Tube Co., Youngstown, Ohio

Louis Moses and M. L. Weikert: Mr. Lambert has gone to considerable trouble in sharing his knowledge

of manipulating and guiding the moving bar by the aid of roller equipment. As he says, rollers have been used for the purpose for many years with modern applications becoming far more than mere conveniences. Original costs and maintenance would not be borne if roller-equipped guides were not virtual necessities and expense returnable through bettered yield or improved products.

Those who do not have the latest designed mills with alternately arranged stands may envy the freedom from twisting which these mills enjoy, but nevertheless the operation can be admirably performed on all horizontal rolls when determination is exercised.

A twisting operation applied to larger cross-sectioned bars than any the paper describes is shown by Figure 26. Except for back end difficulty no trouble occurred in arranging the combination of roller-twist guide "A" and roller-entering guide "B" to perform a 90 degree twist.

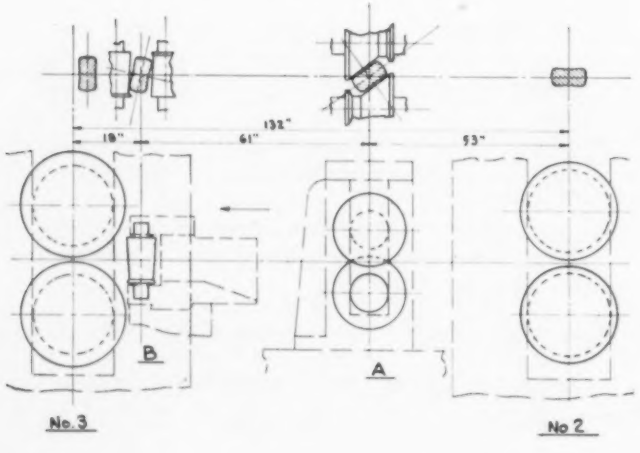
The roller-entering guide "B" was introduced to relieve friction occasioned with plain side guards in front of No. 3 rolls. It was found that the face angle of these, as calculated to a proportionate amount of the total spiral, would not function properly in holding the back-end for continuance of correct entry into No. 3, the back-end leaning into this edging groove.

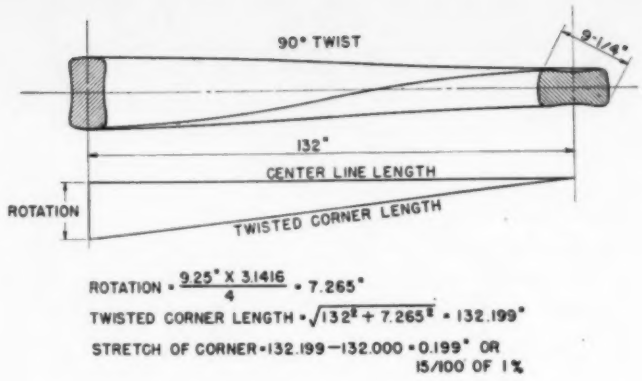
Both guides worked satisfactorily until the bar left No. 2 roll gap. Throughout the forward portion of bar length the desired twist had been successfully induced. What occurred to destroy the continuity of the helix? The beveled roller-twist guide "A" had further twisted an already spiraled back-end. The bar, now being free from any influence of No. 2 rolls, has over-twisted. In somewhat the same manner the entering-roller guide "B" also over-twists.

By trial and error the face angle of entering-rollers "B" was altered from the theoretically figured taper and this, coupled with suitably made adjustments of "A", made the installation a very valuable one in eliminating any scratching whatsoever at this previously difficult position. It has been in successful use since the year 1938.

An interesting finding was had in connection with a

Figure 26 — The roller twist guide shown successfully turns large bars 90 degrees.





$$\text{ROTATION} = \frac{9.25'' \times 3.1416}{4} = 7.265''$$

$$\text{TWISTED CORNER LENGTH} = \sqrt{132^2 + 7.265^2} = 132.199''$$

STRETCH OF CORNER = 132.199 − 132.000 = 0.199" OR 15/100 OF 1%

Figure 27 — The stretch of the corner of a twisted bar is less than normally thought.

30-in. continuous mill reducing large blooms to 4-in. billets and to other sizes of semi-finished. Originally employing alternate twisting between horizontal roll stands, the mill was altered to the alternate horizontal-vertical arrangement. When the revamped mill was put in operation the power load was reduced about 27 per cent.

This additional power over that required for the rolling torque applies in proportionate amount to any twisted delivery but particularly on heavy sections. Most of the effort is expended in the twisting itself but is unquestionably lessened when roller-equipped, as compared to conventional, guides are used.

The forces required to perform twisting undoubtedly leave their influence on the roll surface because the extra friction to overcome anything other than straight emergence must be applied at the roll gap.

An erroneous opinion prevails on the amount of stretch a twisted bar receives at its outermost fibers. This is subject to a simple analysis as shown by Figure 27. It is thus seen that the corners of the twisted slab have lengthened only fifteen one-hundredths of one per cent in eleven feet, hardly sufficient to do any damage to the steel.

Application of these devices is presently quite difficult on multiple stranding rod mills and is receiving serious study. Rollers are used on such mills where the spacing between strands is sufficient to install them. There would be important relief from scratching tendencies if roller equipped guides could be applied to strand centers of as little as $4\frac{3}{16}$ in. Each set of rollers must function and have clearance within such confinement which makes the rollers rather miniature as well as posing problems of material, pins and mountings. Can information be had on such applications to narrow strand centers? It has been proposed to use cemented tungsten carbide for rollers and pins, it being advised that bores and pins would run together without lubrication because of the hardness of the material. Has this material been tried anywhere?

With the primary objective of roller-equipped guides producing a scratch free product, a summary of additional reasons for adoption would consist of lessened power on large sections, a probable bettered roll service, and particularly the stability of bar control due to absence of the wear on conventional friction guides.

Electroplating Rectifiers

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. . . . rectifiers and motor generators both have their place . . . . the proper selection will depend on an engineering evaluation of requirements and on a complete cost analysis . . . .

▲ FOR electroplating, which requires high currents at low voltages, only rectifiers of the metallic type are practical. In gas or mercury vapor filled rectifiers, the internal voltage drop of up to 12 volts would be, in many cases, double the d-c output voltage, indicating that the overall conversion efficiency would be far too low for commercial operation.

The term "conversion efficiency" which was developed especially for rectifiers may be new to some. Broadly speaking, "efficiency" is the ratio of output power to input power expressed as a percentage. In electrical equipment of the kind where both the input and output may conveniently be expressed in watts, the efficiency is the ratio of the output watts to the input watts. This is easy to use in straightforward devices such as transformers, and a wattmeter can be connected in each side to measure the input power and the output power. Input and output wattmeters may be connected also to a rectifier unit and a figure can be obtained showing the "power efficiency," that is the ratio of output watts to input watts.

Unfortunately, although this figure is academically correct, it is not of direct practical use since it ignores the purpose for which rectifiers are used: to convert alternating current to direct current. The output from a rectifier, unless it is filtered, is not pure d-c but, in graphical form, may be visualized as a wiggly line some distance above the zero axis. The average height of the line corresponds to the average voltage (or average current), and the wiggle represents the ripple component in the output.

In almost all uses of d-c (excepting heating which is a rare application), it is the average value of the voltage or current which is important and not the rms or effective value. For instance, in electroplating, Mr. Faraday long ago observed the proportionality between the quantity of metal deposited and the total ampere hours. Where the amperes fluctuate (within reasonable limits), it is the arithmetical average of the amperes which determines the rate of deposition. The rms value is not significant.

Recognizing that the average values of the d-c output are important, the following definition of conversion efficiency has been developed by the Metallic Rectifier Section of the National Electrical Manufacturers Association:

"The conversion efficiency of a metallic rectifier or rectifier unit is the ratio, in per cent, of the product of the average values of direct-current voltage and direct-current output to the total alternating-current power input."

"Conversion efficiency," as defined above, invariably gives a lower figure than "power efficiency" but the member companies of the NEMA Metallic Rectifier Section have agreed to use "conversion efficiency" in their specifications since this value has a real meaning in the practical application of rectifier equipment.

In the late 1930's two types of metallic rectifiers were offered for electroplating in this country—magnesium copper sulphide and copper oxide. These were not used very widely and most units were of small capacity, 6 volts 500 amperes being typical. As early as 1928 a new type of metal rectifier—selenium—had been developed in Europe, but was not introduced here in commercial quantities for over ten years. The reasons for this surprising delay are interesting but not pertinent to this paper. By the late 30's, a number of selenium rectifier units were supplying d-c for electroplating plants in various European countries including France, Germany, Switzerland and England. Some of these installations, for example an 18,000-amp job in England, were considerably larger than average American rectifier installations at that time.

In 1939 the first line of selenium rectifiers designed for electroplating was offered in this country and the ampere rating of individual units increased rapidly so that 3000-amp units were common before the war. Under wartime conditions, the use of rectifier units was accelerated beyond a normal growth curve so that, by the end of the war, rectifiers were the standard power supply source in many companies, and were at least familiar even to those who preferred motor generators.

Immediately after the war many new companies began the manufacture of selenium rectifier units. Some of these have since dropped out, but, at present, perhaps 90 per cent of the makes now offered incor-

porate selenium rectifier elements. One manufacturer still builds copper oxide, another builds copper oxide but has recently added a line of selenium units, and a third, who previously specialized in magnesium-copper sulphide is apparently swinging over completely to selenium. All the others make selenium units only. It is the writer's personal belief that selenium will ultimately be the only type used in electroplating rectifiers, but since other types are still available, a brief discussion may be in order.

COPPER OXIDE

The copper oxide is the oldest metallic rectifier used commercially in this country and is familiar to most electrical engineers. In its original form, which persisted to five or six years ago, the rectifier was of the two-piece type, each rectifying element requiring the junction, under pressure, of an oxide-coated copper disc and a lead disc or washer. Rectification occurred at the interface between the lead and the copper oxide. Because of this two-piece construction, there were a number of disadvantages which have been overcome by the development of the one-piece or "plate" type of copper oxide rectifier. Briefly, in the plate type, the lead washer is eliminated and nickel is electroplated directly onto the copper oxide surface. Rectification takes place at the junction between the copper oxide and nickel surfaces, but assembly pressure is now relatively unimportant since the two surfaces are in permanent contact.

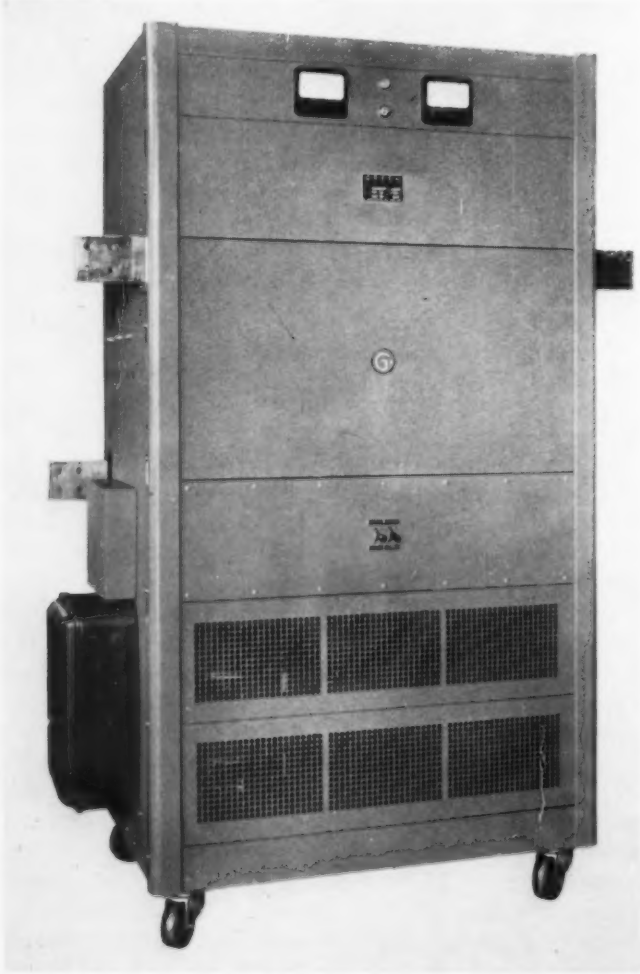
The plate type of copper oxide rectifier has conversion efficiencies comparable to the selenium rectifier and at low voltages, of the order of 2 or 3 volts, can actually have higher efficiency if an appropriate circuit is used. Safe operating temperature is lower than for selenium, and copper oxide plates are run at lower current densities—that is, at lower amperes per square inch of rectifying area. For these reasons copper oxide rectifier units tend to be bulkier than selenium units of the same rating, and greater air volume is required to keep the plates at sufficiently low temperatures.

Per plate, the copper oxide has an inverse voltage rating which is only a fraction of the rating for selenium plates. This parameter will be discussed under "Selenium" but, in passing, it may be noted that copper oxide units frequently incorporate an over-voltage relay to limit the voltage applied to the plates in order to avoid breakdown from this cause.

On the credit side it should be noted that copper oxide plates are still cheaper to manufacture than selenium plates, although automatic processes developed during the war have brought down selenium costs considerably.

Although the copper oxide plate type is relatively new (compared to the more than 20 years of the selenium rectifier), its life characteristics appear to be good. The single-piece construction should, of course, eliminate a difficulty which was inherent in the lead washer type—increasing contact resistance with thermal expansion and contraction.

Figure 1 — A large selenium rectifier unit for remote control.



MAGNESIUM COPPER SULPHIDE

This type of metal rectifier is nearly as old as the copper oxide and, like the original copper oxide, is of the two-piece type. The two pieces are a magnesium washer and a copper washer with a copper sulphide surface. Rectification takes place between the copper sulphide and magnesium surfaces and considerable assembly pressure is required to maintain effective contact.

The magnesium copper sulphide rectifier has a number of advantages including cheapness, ruggedness, ability to withstand comparatively high temperatures, and a certain measure of "self-healing," that is, the ability to recover from punctures due to overvoltage. A large number of these units were put into service during the war.

The chief disadvantage of the magnesium copper sulphide rectifier for use in large installations is its low overall conversion efficiency. No single figure is applicable to all units, but the following figures are representative of comparative conversion efficiencies:

Selenium and copper oxide plates. . 65-70 per cent
Magnesium copper sulphide. . . . . 45-50 per cent

A second disadvantage of the magnesium copper sulphide rectifier is that its conversion efficiency decreases rather rapidly with use and apparently continues to decrease without levelling off. Ultimately, the increas-

ing temperature rise or decreasing conversion efficiency, or both, require replacement of the rectifier stacks.

AGING

"Aging," which has tentatively been defined as any permanent change in electrical characteristics, occurs also in copper oxide and selenium plates, but at least in the selenium type occurs at a much slower rate and tends to level off at values which still permit continuous operation at rated current and at satisfactory conversion efficiencies. Properly designed selenium units include a margin to allow for this effect so that full output is available even after the initial aging process.

Aging information on copper oxide plates is somewhat ambiguous perhaps because of the lack of field data. Some published material claims that no change in characteristics occur—that is that there is no aging —whereas other information, supplied for design purposes, indicates a possible increase in forward resistance of as much as 100 per cent. Incidentally, since the internal forward resistance of the rectifier is generally only a fraction of the load resistance, an increase of 100 per cent will not produce quite as much voltage drop as might at first be supposed. Increase in forward resistance will, however, result in increased internal losses and greater temperature rise.

SELENIUM

The selenium rectifier plate is of the one-piece type which means that its successful operation is substantially independent of contact pressure. In its original form, steel was used for the base plate, but during the war aluminum plate elements were developed. The aluminum type has obvious advantages of decreased weight and the elimination of rust corrosion.

In either type, amorphous selenium with traces of rare earth halides are spread on the base plate, compacted, and heat treated to convert the selenium to the crystalline form. A low resistance, low melting point, alloy is sprayed or evaporated on the selenium surface, and this is followed by an electrical forming process using steadily increasing voltage.

Rectification takes place between the alloy surface and the crystalline surface of the selenium. The steel or aluminum base plate serves merely as a support and to carry current to the "back" of the selenium layer. After testing, the plates are assembled into multiple or series "stacks" and, for most industrial applications including electroplating, the stack is finished with a number of individually baked protective coats to protect the assembly against moisture and corrosion.

Selenium plates first made in this country were in the form of circular discs varying in diameter up to 4⅜ in. maximum. At that time, just before the war, the largest discs—of 4⅜ in. diameter—had a maximum inverse voltage rating of 14 volts rms (about 20 volts peak). Although already high compared to other types of metal rectifiers, there has been a considerable increase since then and inverse voltage ratings of 26 volts rms (36 volts peak), or more, are now quite common.

Another useful development in the selenium rectifier art is the manufacture of comparatively large rectangular plates with areas of three or more times the area of the prewar 4⅜ in. disc. Typical rectangular plate sizes are 5 x 6 in. and 6¼ x 7¼ in. The rectangular plates, when assembled in stacks, permit compact, well-ventilated, designs in which as much as 50 kilowatts d-c including controls, requires a floor area of only about 7 or 8 square feet.

Mention has already been made of the high inverse voltage rating of the selenium plates. This, together with moderately high permissible current density, accounts for the comparatively small size of selenium rectifier units for a given rating. For example, the optimum circuit for 12 volts output using selenium is a three-phase wye having only three arms and only one series connection per arm. In contrast, copper oxide would require a three-phase bridge with six arms and two series connections per arm, making a total of at least four times as many plates, without taking into account the increased area required by the lower permissible operating temperature of the copper oxide type.

For six volts output the wye circuit with three arms is still the optimum circuit for selenium, whereas copper oxide units use the six arm bridge, that is, twice as many plates.

It is argued that the bridge circuit has a lower percentage ripple than the wye circuit (4.2 as compared to 18 per cent) and also that the bridge should be more efficient. The first of these statements is correct, the ripple in the d-c output from the bridge is less and in some applications this might be a factor. However, in electroplating, there is apparently no difference in the results obtained from bridge and wye rectifiers.

The efficiency argument is generally based on a mathematical analysis of theoretical circuits using ideal rectifiers of zero resistance. It should be noted that, in the bridge circuit, the current flows through more than one arm in series, and, in the wye circuit, through one arm only. Therefore, in practical rectifier units, the real internal resistance of the rectifier arm plays an important part and the selenium unit with wye circuit is found to be at least equal in conversion efficiency to the copper oxide bridge at the voltages and currents commonly used for electroplating.

ADVANTAGES AND DISADVANTAGES OF RECTIFIER UNITS

Since the only other type of d-c power supply commonly used for electroplating is the motor generator, "advantages and disadvantages" must imply "as compared with motor generators."

The motor generator has, from an engineering standpoint, the very real advantage of about a century of steady development and improvement. The modern motor generator, of the better makes, is a very fine machine and it would be foolish to claim that generators have become obsolete just because rectifiers have been introduced. For any particular job, the choice between the two power supplies should be based on a careful study of cost and engineering factors. It must constantly be remembered that, although both types of equipment convert a-c to d-c, they are fundamentally different in construction and in many performance characteristics. The motor-generator is superior in

some characteristics and the rectifier in others. Here are some of the major factors to be considered.

EFFICIENCY

A motor-generator set is usually designed to develop peak efficiency at full load. Under *ideal* conditions, with commutator and brushes in perfect condition, a good motor generator may have a peak efficiency of 75 to 80 per cent. However, the average overall efficiency over a period of time, under practical conditions, is lower than this for two reasons:

1. The commutator, brushes, and brush adjustment, are perfect only when new or immediately after a routine overhaul. Between overhauls the efficiency drops until the next overhaul.
2. When operating at less than full load, motor generator efficiency decreases because of the comparatively large fixed losses.

According to the comments of operating people in the electroplating field, an average efficiency of 65 per cent or, in some plants, 70 per cent is a realistic practical value.

Selenium metal rectifier equipment can easily be built to operate with overall conversion efficiencies of as high as 85 per cent. This can be achieved in a three-phase circuit running the plates at their natural-cooled current density. In practice, equipment of this kind, excepting for comparatively small current ratings, is too bulky and too expensive. Safe continuous current rating of a given area of selenium can easily be increased by artificial cooling. Theoretically, the current rating can be increased to as much as ten times the natural-cooled rating but, due to increased internal resistance losses, this results in conversion efficiencies which would be out of the question excepting for some very special applications (for example in some aircraft uses) where small size and low weight are the primary considerations.

Careful studies, confirmed by some years of field experience, have shown that a factor of 2½ times the natural-cooled current density will result in a design which provides optimum compromise between the factors of conversion efficiency, size, and initial cost. Properly engineered selenium rectifier units of this type have a full load conversion efficiency of between 65 and 75 per cent at usual electroplating voltages. Somewhat higher conversion efficiency can be obtained by operating the plates at a lower current density, for example at a factor of only two times and, provided there is no corresponding reduction in ventilation, there is also an increase in safety and overload margin. This is the factor recommended for steel mill rectifier equipment.

It is worth noting that the conversion efficiency of rectifier units, unlike generators, tends to increase as the load decreases. This is because the fixed losses are quite small, and the internal loss due to forward resistance of the rectifier plates falls off rapidly as the load current is reduced. In typical selenium units, the conversion efficiency, at half load, will be about 5 per cent above the full load efficiency, and will be equal to the full load efficiency at about 15-20 per cent of the full load rating. This means that conversion efficiency is high over an extremely wide range of loads.

Figure 2 — This master remote control unit with automatic features is used for a group of rectifier units.

OVERLOAD

The mass of metal incorporated in a rectifier unit is considerably less than that required for a motor generator of similar rating. Therefore, the rectifier has a lower thermal capacity and its temperature rise will respond more quickly to changes in current. In general, for any specific set of conditions, a typical plating rectifier will achieve thermal stability in a period of 20 to 30 minutes. For this reason it is unrealistic to insist on comparing the overload characteristics of these two entirely different types of electrical devices on the two-hour basis which was developed for the motor generator. It is fairly accurate to say that if a rectifier unit can operate without danger for two hours at a particular load, it can be expected to operate indefinitely at that load.

Where intermittent overloads form part of the requirements, the rectifier engineer can manipulate either or both of two design parameters, depending upon the extent of the overload, the period of overload, the expected frequency of overload and the importance of power cost. These parameters are:

1. The rectifying plate area. By increasing the area the current density will not be abnormally high under overload conditions. The conversion efficiency will be increased for both normal and overload conditions.
2. The volume of cooling air. This may be increased to a value such that under the anticipated overload conditions the temperature of the rectifier elements cannot reach a point at which the plates would be damaged.

Because of the steel industry's rating habits it is recommended that plate area should be somewhat greater than that which would normally be used, and that ventilation should be proportionately increased. It is entirely practical to build selenium rectifier equipment to meet any specified load or overload conditions without sacrificing any of the advantages peculiar to rectifier equipment.

INITIAL COST

In general, the best rectifier equipment costs less than the best motor-generator equipment. Where design (of either type of equipment) has been skimped in order to cut costs, price comparisons become meaningless.

In comparing initial costs, the cost of installation must be taken into account. For motor generators it is necessary to provide firm level foundations as for any heavy rotating machinery. Rectifiers have the edge here because their floor loading factor is less and they are much easier to install. Some makes of rectifier units are equipped with casters or wheels so that they may be rolled into place. If the rectifier units are of the kind with built-in controls, the electrical installation is also simple as compared to a motor generator set which may require the separate installation of a starter panel and control board, and possibly a separate exciter unit.

Both kinds of equipment, particularly in large installations, may require the provision of ventilation ducts, with or without auxiliary blower fans. Rectifier units generally have built-in fans, but if the ducts are long or narrow, additional fan capacity may be needed to compensate for the air resistance of the duct. Incidentally, if the two kinds of equipment are equal in efficiency, then it follows that the heat losses are identical and the same number of Btu's must be removed. However, rectifiers are in general more susceptible to permanent damage from overheating and therefore adequate ventilation is more important.

It is not practical, at this stage of the art, to specify a figure of "dollars-per-ampere" or "dollars-per-kilowatt" for estimating the cost of rectifier equipment. Variables such as the d-c terminal voltage, type of voltage control and other auxiliaries, overload factor, etc., all affect the cost. About all that can be said on this subject is to repeat that the installed cost of the best rectifier equipment is comparable to the installed cost of the best motor generator equipment.

MAINTENANCE

Properly designed and properly operated rectifier equipment, according to reports from operating men, costs less to maintain than motor-generator equipment. This would be expected since the motor-generator is a rotating machine requiring regular replacement of brushes, and dressing of commutators. The frequency with which these routines are carried out depends upon the conscience of the maintenance department and the value placed on efficiency.

With the exception of fans, rectifier units are largely static and require comparatively little work to maintain. Recommended maintenance routines include chiefly regular fan lubrication and regular removal of accumulated dirt, particularly from the assemblies of rectifier plates. An unexpected but not entirely strange development is that since rectifier equipment requires only a little maintenance, they therefore receive none in some plants with consequent failure and a black eye for rectifiers.

Those parts which may ultimately require replacement are comparatively inexpensive and easy to change —such as pilot lamps, contacts on magnetic switches, fan motors. Major components are discussed under "Life."

LIFE

The two kinds of major components in rectifier equipment are transformers and rectifier stacks (assemblies of plates). Both of these are static and will not fail from mechanical causes.

Transformers can be disposed of quickly. If they are designed for the job they should last indefinitely. There is no excuse for transformer failure in normal operation. Particularly for electroplating applications, the transformer design should feature inorganic insulation and thorough impregnation to eliminate corrosion troubles. Also, the electrical rating should be conservative so that temperature rise is within approved limits for the type of construction. The rms currents in rectifier transformers may be higher than in other types of transformers, and the copper size must be specified to suit.

The following comments are based on experience with selenium rectifier stacks but some of these apply also to other types of metal rectifiers.

It has already been pointed out that selenium rectifier plates have high inverse voltage ratings. This provides a considerable margin of protection against overvoltage so that failure from this cause is practically unknown. Excessive current, as such, does not damage selenium rectifiers. It is excessive plate temperature which causes either failure or rapid aging, and the plate temperature is, in turn, a function of: ambient temperature, watts loss in the plates, and ventilation, i.e., rate of removal of heat. All three of these factors are well known to experienced designers of rectifier equipment, and with conservative engineering there is no reason, excepting a desire to cut costs, why rectifier plates should be subjected to abnormally high temperatures. The trend in recent years, among builders of better rectifiers, has been toward more generous plate area and more ventilation—both aimed at reducing temperature rise and increasing the margin of safety. It is desirable to have such conservative design backed by protective devices such as thermostat-operated warnings or cutouts—even if such devices never operate. They provide insurance against blocked ventilating systems, fan failure, etc.

CORROSION

Another possible cause of rectifier plate failure, particularly in electroplating applications, is corrosion from acid or alkali fumes, or, in unusual cases, actual abrasion from gritty air. The better types of rectifier stacks are finished with a number of individually baked coats of moisture and corrosion resistant materials, of which bakelite resin varnish is a typical example. Although such finishes have survived up to 200 hours boiling salt spray and 48 hours acid and alkali tests, no finish will indefinitely withstand perpetual attack from corrosive vapors. For this reason, rectifier manufacturers generally recommend that rectifiers be installed with the same care as any other electrical equipment. When analyzed, this means chiefly that the incoming

air should not be drawn from directly over the plating tanks. Thoroughly conditioned air is not required, but the air should be breathable. The writer knows of more than one case where air ducts were installed leading to the outside of the building and the intake was then located only a few feet from the exhaust leading from a chromic acid tank.

In special cases, the only available air may be loaded with abrasive dust or grit (which, incidentally, would be harmful to rotating machinery as well as rectifiers). In such locations, it may be necessary to install air filters at some point in the air intake system. Generally the air-flow resistance of the filter will indicate the need for an auxiliary fan or blower since standard rectifier units are not generally equipped with built-in fans with sufficient capacity to suit the occasional location where filters are used.

FLEXIBILITY

A particular feature of rectifier equipment, different from the dynamo and generator machines previously used, is the extreme electrical flexibility. Units may be paralleled indefinitely to obtain any desired maximum current capacity. Similarly, rectifier units may be connected in series to get higher voltages. This flexibility is of practical importance in several ways. First, current capacity can be boosted at any time after the original installation if operation at higher speeds is desired. Similarly, tank voltage can be increased to permit the adoption of improved electrolytic processes requiring higher tank voltages. Secondly, units may easily be rearranged to shift current capacity from one part of the plant to another, or spare units can be added for a temporary increase in capacity, or to replace units which have been damaged and need repair or overhauling.

This electrical flexibility is matched by physical flexibility. Even a 5000-amp selenium unit is compact and comparatively mobile, particularly if it happens to be caster-mounted. The fact that the floorloading index is low and that a dead level foundation is not required has previously been pointed out.

In large installations requiring considerable current capacity, the total load will inevitably have to be divided between a number of similar rectifier units, which may all be connected to a common point, or more frequently, connected to anode and work terminals distributed along the length of the machine. The latter arrangement results in more uniform current distribution, and also permits variation in operating potential along the process route, in case this is found to be desirable.

In connection with the use of multiple units, two points should be noted.

First, as compared to operation from a single large power supply source, the risk of breakdown is subdivided in proportion to the number of individual units, and the possibility of shutdown is reduced since it is generally feasible to continue operation at a lower rate, with one or more units disconnected.

Second, there is no increase in cost because of subdivision. Above a certain physical size there is no economy in making individual rectifier units still larger. In fact, because of difficulty in handling at the manufacturing end, and in installation, the cost in dollars per ampere may actually increase.

Two other kinds of electrical flexibility are available in the individual rectifier units—input flexibility and output flexibility.

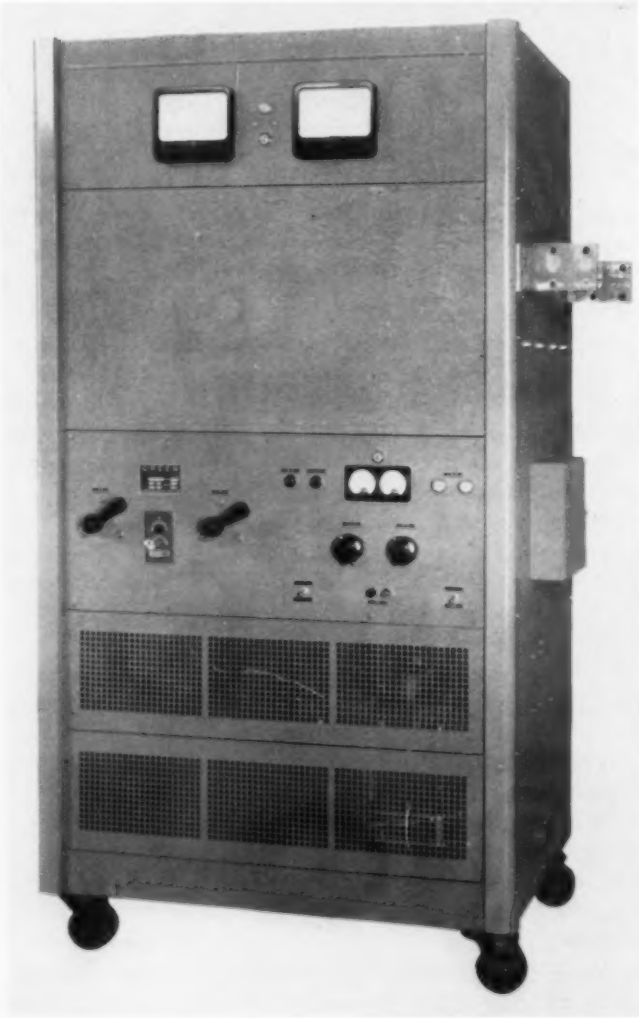
Since the a-c input is fed to the primary of a transformer, it is a simple matter to arrange the primary windings with taps and interconnections for operation from a variety of input voltages. Many standard units can now be connected to operate from 210, 220, 230, 420, 440 or 460 volts three-phase supply.

Similarly, the secondaries may be divided into two or more groups, each group feeding a separate set of rectifier plates, thus providing a number of individual d-c outputs which may be connected to obtain different voltage ratings and current capacities. Such arrangements are most frequently used in small units for laboratory or test work, but "dual output" such as $^{6}/_{12}$ volts or $^{9}/_{18}$ volts is common on large industrial rectifier units.

VOLTAGE CONTROL

The d-c output from rectifier units can most conveniently be controlled by adjusting the voltage sup-

Figure 3 — Rectifier unit has built-in controls including automatic current stabilization.



plied to the primary side of the stepdown transformer. Any devices suitable for insertion between commercial power lines and transformer primaries may be used such as tapped transformers, continuously variable (movable brush contact) transformers, induction regulators and saturable reactors. There is not time to discuss the merits of these various methods, but it may be noted that all of them have been successfully used. Some of these voltage control devices are available with remote motor-driven control which can easily be associated with automatic devices to maintain constant voltage, constant amperage, or to connect the voltage or current value with some other process factor such as speed of the work through the electroplating machine.

Automatic controls are necessarily more expensive than the usual manual controls, and are usually justified only for high-speed full-automatic processing where the rate of production can pay for the additional cost. Individual rectifier units of standard type are available in three forms from most manufacturers—without voltage control, with built-in manual voltage controls, and with remote manual voltage controls. The most common type of manual control is a tapped auto-transformer and rotary tap switches.

RECTIFIER SPECIFICATIONS

The purpose of specifications is to exchange information between the prospective user and the rectifier builder, so that there is a sound connection between requirements and equipment design. There are two kinds of specifications, those prepared by the user and those prepared by the builder.

The specifications prepared by the user, should give following minimum information.

1. For what purpose is the d-c required?
2. What is the maximum continuous d-c amperes required and at what voltage?
3. If the d-c voltage must be varied, over what range?
4. What a-c power supply is available for the equipment?
5. Any unusual service conditions such as ambient temperatures exceeding 40 C (104 F), altitude exceeding 1000 meters (3300 ft), corrosive or dirty air, etc.?
6. Any special features such as remote or automatic controls?

There are two extremes of specification writing which, in the author's opinion, are wrong. One is to give the manufacturer no information but to request "a catalog and price list." The second, is to prepare an unnecessarily detailed specification, again without first consulting the manufacturer. This procedure implies that the manufacturer does not know his business, in which case you are dealing with the wrong manufacturer.

Most rectifier applications are straightforward and not entirely new (even though they may be new to the user) and a rectifier manufacturer with some experience and a wide line of equipment can, in a great many cases, select standard units to do the job. If the application is really unusual you will get a request for more information, and if the job is of any magnitude, your engineers and the rectifier engineers can get together to work out the requirements.

Particularly on special jobs, manufacturer's specifications should be requested and analyzed. The reasons for differences in price may be indicated in the specifications. Points which may indicate differences in engineering approach and quality of construction are:

1. What is the total area of rectifier plates?
2. How are the rectifier stacks finished for protection against corrosion and moisture?
3. As an index to ventilation efficiency, what is the specified maximum temperature rise of rectifier plates under full load?
4. What are the kva ratings of the transformers for normal temperature rise?
5. How are the transformers constructed with regard to insulation and impregnation?
6. What protective devices, such as thermostats, current overload relay, anti-single phase relay, etc., are included?

In conclusion, the writer would like to suggest that prospective purchasers or users of rectifier equipment study "Standards for Electroplating Metallic Rectifier Units," available from NEMA. These standards contain a great deal of data which could not be incorporated in this paper.

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AUTOMATIC CONTROL

for

MULTIPLE FUEL-FIRED BOILERS

By MITCHELL J. BOHO
Vice President
Hagan Corp.
Pittsburgh, Pa.

. . . . constant improvement is being continually achieved in the design of automatic control equipment . . . .

▲ IT was just about twenty-one years ago that the first combination fuel-fired boiler house specifically designed to use automatic combustion control was placed in operation at the Campbell works plants of Youngstown Sheet & Tube Co. There was considerable skepticism in many minds at that time as to the practicability of such an installation, and at least one major control manufacturer declined to quote on the control equipment. This plant included several novel features, major among which was the automatic starting and stopping of pulverized coal burners to supplement blast furnace gas firing. The installation was a success from the start, and it is significant that the plant is still in every-day operation using the original automatic combustion control equipment. Since that time, many such plants have been designed, built, and operated with such success, that today no major steel plant boiler installation is made without automatic combustion control as a part of the original design. Indeed, it is difficult to imagine how some of these plants could be operated without such controls.

Steel mill boiler plants differ from the usual industrial installations in that blast furnace gas is the predominant fuel. Because the availability of blast furnace gas does not parallel steam demand, and because storage facilities generally are not available, it is necessary to supplement blast furnace gas with some other auxiliary fuel, such as coal, oil, or coke oven gas. Steel mill boilers are often called upon to carry such large and sudden load changes in regular operation, as would correspond to emergency conditions in most industrial plants. One plant, of which we know, is called upon to handle load swings as high as 28,000 kw in two or three seconds, at intervals of two or three minutes, continuously except for periods of relatively calm load when roll changes are made in the hot strip mill.

A typical installation of this early period included boilers fired by blast furnace gas on one side of the furnace, and coal from separate burners on the opposite side. The fuel control circuits involved jackshafts and mechanical transmission to coordinate the operation of the fuel and air controls. Air flow was regulated using damper position as the measure of flow, and the blast furnace gas and auxiliary fuel were treated as if fired in separate furnaces, using steam pressure as the coordinating factor. This calibrated position control was practical because the air supply system for each fuel could be separately calibrated with its fuel and burner system. These early installations included two separate steam pressure masters, one set for a slightly lower steam pressure than the other, so that as steam pressure fell, indicating the lack of enough blast furnace gas to carry the load, the second master control operated to make up the deficiency by the admission of an auxiliary fuel and air supply. Despite the lack of refinement, these early installations, practically all of which are still in operation, were basically correct and initiated the chain of advancements which characterize the modern systems of today. These advancements are partly apparatus improvements and partly circuit developments, necessary to keep pace with the more involved firing systems and burner arrangements.

Since the arrangement of automatic control is dependent, to a large extent on the nature of the boiler equipment to be controlled, it would be helpful to consider representative modern firing and fuel arrangements, as shown by nine more recent designs, the control equipment for which were or will be supplied by the author's company. See Table I.

It is interesting to note that the trend seems to be towards turbine-driven forced and induced draft fans and multiple fuel burners, with a common air supply. Coke oven gas and oil appear as either supplementing or replacing coal as the main auxiliary fuel.

The use of multiple fuel burners makes it imperative that the several fuels be separately measured and totalized in such a manner that the result of the totalization is a control signal, which is a measure of the total air required. This means that not only must the fuel be measured, but the measurement be weighted by the air requirement factor for that fuel. In addition, where

TABLE I

Plant	Fuels	Burner air supply	Fan drives
Great Lakes Steel Corp. Ecorse, Mich.	Blast furnace gas Coke oven gas	Common	Steam turbines
Carnegie-Illinois Steel Corp. Gary, Ind.	Blast furnace gas Fuel oil	Common	Steam turbines
Alan Wood Steel Co. Conshohocken, Pa.	Coke oven gas Blast furnace gas Fuel oil	Common	Steam turbines
Carnegie-Illinois Steel Corp. Edgar Thomson Works Braddock, Pa.	Blast furnace gas Pulverized coal	Separate	Steam turbines
Steel Co. of Canada, Ltd. Hamilton, Ontario	Blast furnace gas Coke oven gas Fuel oil	Separate	Steam turbines
Carnegie-Illinois Steel Corp. Carrie Furnaces Rankin, Pa.	Blast furnace gas Pulverized coal	Common	Steam turbines
National Tube Co. McKeesport, Pa.	Blast furnace gas Pulverized coal	Common	Steam turbines
Bethlehem Steel Co. Sparrows Point, Md.	Blast furnace gas Fuel oil	Separate	Motors through hydraulic couplings
Colorado Fuel & Iron Co. Wickwire-Spencer Div. Buffalo, N. Y.	Blast furnace gas	Common	Boiler damper forced draft fan turbine

the air flow must be measured in the combustion passes of the boiler, it is necessary for the air flow measurement to be compensated for the radical difference in the composition of the flue gases when going from straight blast furnace gas to mixtures of blast furnace gas and other fuels.

It is desirable, in addition to maintaining proper fuel-air ratio, to so control the admission of fuel that at all times the fuel input to the furnace after a change in fuels shall remain the same as before the change and at no time should the fuel supply exceed the air available for proper combustion.

These are basic requirements which have called forth basic advances in the engineering of control circuits.

There are also other very practical requirements which tax the versatility of the control system; for example, it may not be an economic matter to design the induced draft system for full boiler load capacity under straight blast furnace gas firing because the fans would be excessively large. Nevertheless, it is desirable to per-

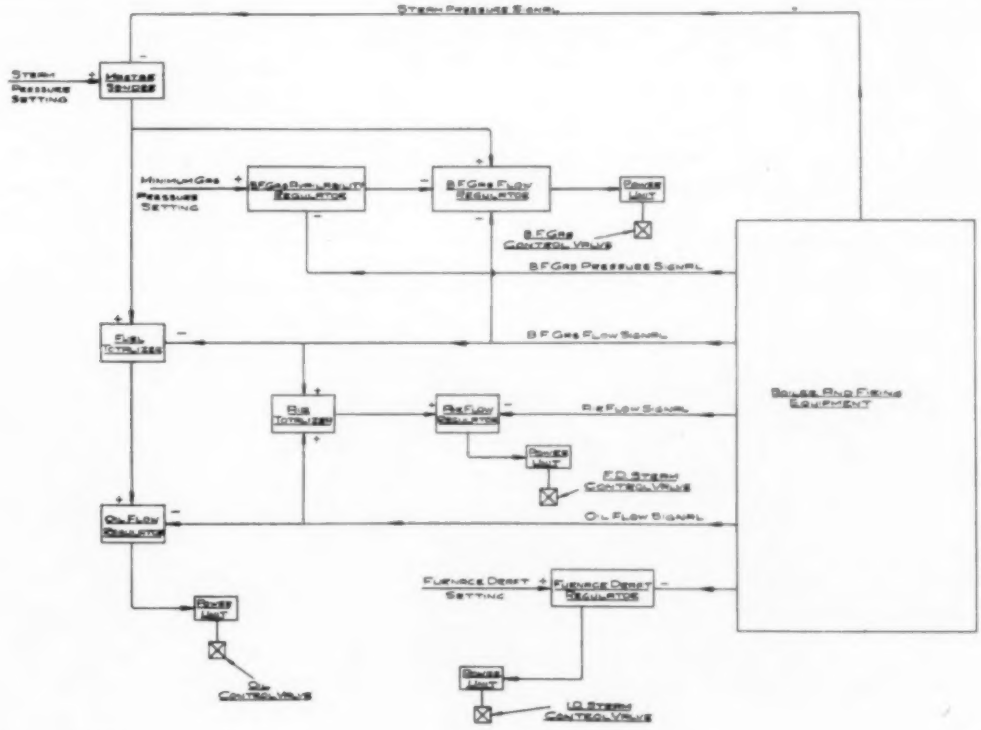


Figure 1 — Functional diagram of control system for multiple fuel-fired boiler.

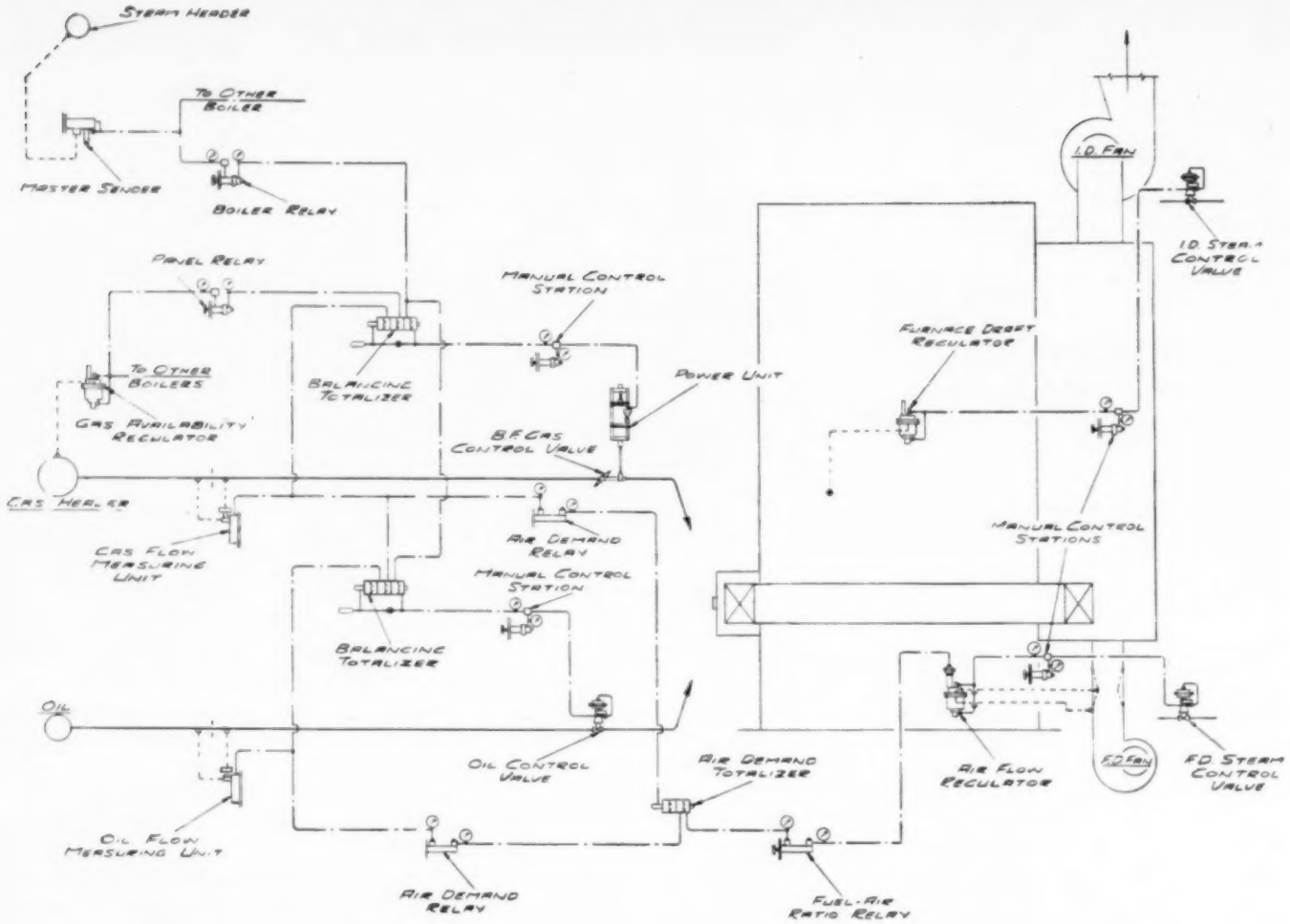


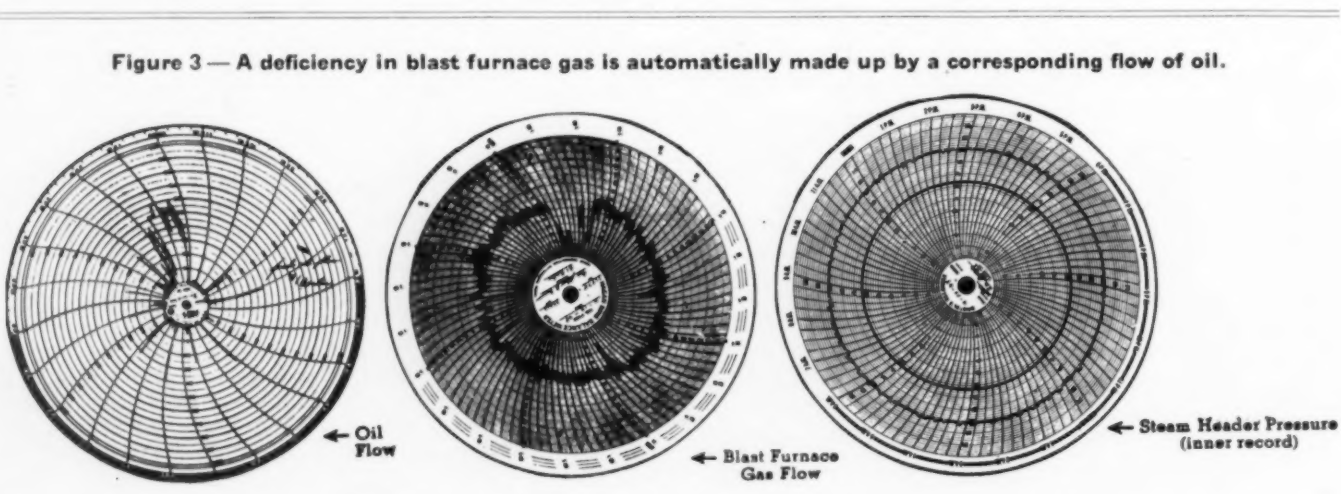
Figure 2 — Apparatus diagram of control system — multiple fuel-fired boiler.

mit such firing at times. One method of handling this problem involves by-passing the air heater or economizer as the fan approaches full speed. The control arrangement must not only do this automatically, but at the same time maintain the maximum possible heat transfer.

In working out some of these advanced circuit requirements, it has been necessary for apparatus design to keep abreast of progress; for example, in the control of turbine-driven fans, at one time it was considered necessary to operate dampers in connection with turbines so as to provide a micrometer type of control. The development of stable high speed diaphragm type regulators has made the use of dampers unnecessary, the resultant control being simpler and superior to that obtained by the former combination damper-turbine speed type of control.

A pneumatic totalizing apparatus has done away with the jackshaft and lever systems formerly used to combine control functions.

Figure 3 — A deficiency in blast furnace gas is automatically made up by a corresponding flow of oil.



High speed diaphragm type metering regulators have taken the place of the cumbersome float operated devices of years ago, not only measuring the differentials but extracting the square root function before sending out the pneumatic control signal which represents the metered flows.

With the foregoing as a background, it will be of interest to consider a typical modern installation incorporating many of the ideas which have been discussed. Figure 1 illustrates such a system, using the newly developed functional block diagrams being considered by the A.S.M.E. Terminology Committee as a means of illustrating the overall strategy of a complicated control arrangement in a simple manner.

Referring to this diagram, it will be noted that the system includes three primary regulators which must be satisfied to accomplish the desired overall results. They are the master sender which regulates steam pressure, the blast furnace gas availability regulator which protects the blast furnace gas supply, and the furnace draft regulator which insures removal of the products of combustion. Starting with the master sender, a pneumatic control signal is generated in accordance with fuel demand. This control signal is transmitted to the blast furnace gas regulator and also to a fuel totalizer. The blast furnace gas regulator, in response to this loading, transmits a control pressure to the power unit controlling the opening of the blast furnace gas control valve, causing it to open. The amount of blast furnace gas flowing, as a result of the valve opening, is measured and fed back to the blast furnace gas regulator where it opposes the loading set up by the master sender. When sufficient blast furnace gas is available, the regulator is in equilibrium when the flow of blast furnace gas is equal to that desired, as indicated by the master sender loading. If at any time the supply of blast furnace gas should decrease, as indicated by a falling-off in incoming blast furnace gas pressure, the blast furnace gas availability regulator generates a pneumatic signal, which is transmitted to the blast furnace gas regulator opposing the master signal and causing the blast furnace gas regulator to reduce the flow of blast furnace gas until the maximum amount of gas available is being used.

The total fuel loading from the master sender is also transmitted to the fuel totalizer, where it is opposed by the pneumatic signal representing blast furnace gas flow. The difference between these two signals represents the deficiency in fuel that must be made up in the form of oil. This deficiency signal is transmitted to the oil flow regulator, which controls the opening of the oil valve, permitting oil to flow to the burner until the rate of flow represented by the oil flow signal is equal to that coming from the fuel totalizer. If the blast furnace gas available should increase, the amount of oil flowing would correspondingly decrease, and vice versa.

For purposes of air flow control, the blast furnace gas flow and the oil flow signals are both combined in a correct manner to generate a total air flow requirement signal, which is transmitted to the air flow regulator and opposed by the air flow signal representing actual air flow. The difference between these signals actuates a forced draft steam control valve, adjusting the speed of the forced draft fan turbines as required to set up the proper flow of air.

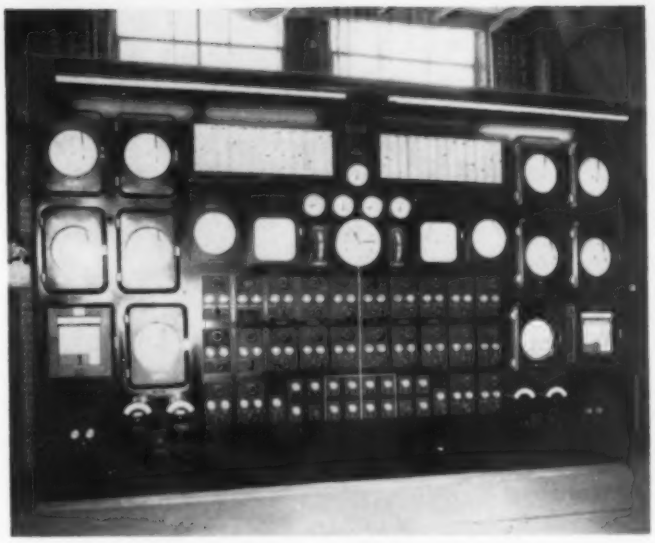


Figure 4 — Centralized control panels enable convenient operation of the combination fired steel mill boilers.

As noted, the furnace draft regulator is a separate entity which operates to control the opening of the induced draft fan steam control valve, as required to maintain the desired furnace draft within the combustion chamber.

Figure 2 is an apparatus diagram corresponding to the functional diagram of Figure 1.

Figure 3 illustrates the control action of the above described blast furnace gas and oil control system. Note the places on the chart where a deficiency in blast furnace gas is automatically made up by a corresponding flow of oil to maintain the fuel input at the desired value.

Figure 4 illustrates the control panel carrying the control and instruments for two recently installed combination fired steel mill boilers.

DISCUSSION

PRESENTED BY

E. S. SEELY, Power and Fuel Engineer, Carnegie-Illinois Steel Corp., Homestead Works, Munhall, Pa.

M. J. BOHO, Vice President, Hagan Corp., Pittsburgh, Pa.

H. R. FULTON, Mechanical Engineer, Bailey Meter Co., Pittsburgh, Pa.

C. W. PARSONS, Assistant to Vice President, Republic Flow Meters Co., Chicago, Ill.

B. D. BARNS, Superintendent Fuels, Ford Motor Co., Rouge Plant, Dearborn, Mich.

E. S. Seely: On a boiler equipped with four combination type burners, suitable for firing either blast furnace

gas, the primary fuel, or coal, the secondary fuel, what difficulties are encountered in obtaining the proper fuel-air mixture when it is necessary to clean the gas compartment of one of the burners? At this time an equivalent amount of coal is fired to supplant the blast furnace gas and the combustion controls call for additional air to burn the coal. However, the additional air is being supplied by a common duct which is not directed specifically to the coal burner, but is divided proportionately among the three gas burners and one coal burner. Will the air deficiency at the coal burner result in delayed combustion taking place in the superheater zone?

M. J. Boho: There are a number of factors involved. The combustion control can only regulate the quantity or air supplied for combustion. It is the function of the burner to thoroughly mix the air and fuel so that complete combustion takes place. If the burner is such that dirt deposits affect burner mixing, then combustion conditions will be affected. If separate gas and coal burners are used, it is desirable to shut off the air passages of a burner when it is taken out of service for cleaning. In this way, the combustion air is diverted to the burners which are currently fed fuel. Where combination burners are used, cleaning of the blast furnace gas passages has little effect on combustion since the normal path of air flow through the burner is the same whether gas or coal is being burned. A properly designed combustion control system takes into account the relative difference in air requirements of the blast furnace gas and coal.

H. R. Fulton: I would like to comment on the queston of controlling fan dampers versus fan turbine speed. The results obtained may not depend so much upon the combustion control equipment as upon the inertia of the fan with its turbine and the type of governor used, if any. The speed can be controlled satisfactorily over the normal operating range, but if there is no governor on the turbine it may become unstable below 30 per cent of maximum speed. Hence, a damper must be used to supplement the speed control if regulation is desired at lower loads.

For example, in a recent installation, the forced draft fans were conservatively designed so that a 3:1 range of speed control on the fan represented only a 2:1 range of control on the boiler. With the fan control valve completely closed, sufficient air was passed by natural draft to carry 50 per cent load on the boiler. Obviously, a damper control was needed for the lower ratings. Therefore, one cannot assume that damper control is unnecessary unless these other factors have been carefully considered.

M. J. Boho: It is true that where steam driven variable speed fans are used, the fan equipment must be sized to match the operating range of the boiler. This, however, is true also where damper controls are used. There have been enough variable speed turbine driven fan installations made in the steel industry to indicate that satisfactory designs can be developed. With proper regulating apparatus, results are satisfactory.

C. W. Parsons: Do you have any preference in the control of furnace draft, either as you have shown by the induced draft fan or dampers, or, on the other hand, by the forced draft fan or its dampers?

M. J. Boho: This is a question that could stand a great deal of discussion. In general, we feel that the particular conditions surrounding a given installation determine whether the forced draft or induced draft will be controlled primarily from furnace draft.

In some installations subject to boiler tube slagging, it may be desirable to place furnace draft control on the induced draft; otherwise, furnace fluctuations due to lancing can cause sudden and wide undesirable variations in air flow to the burners. In other cases, the relative speed of response of the forced and induced draft equipment may be a determining factor since, in general, the induced draft fan is much larger and has greater inertia than the forced draft fan.

In still other cases, the question of safety interlock may be considered more important than the other factors. There is a natural interlock present in the operation of the forced draft control from furnace draft. For example, failure of induced draft, through the furnace draft regulator, will cut down on forced draft to a point corresponding to the reduced capacity of the induced draft fan. The fact that the furnace draft regulator is in continuous operation makes it a more desirable safety element than a special device which may not be called upon to operate more than once or twice throughout its useful life.

From the above, it will be apparent that there are several, and in some cases conflicting, considerations which must be taken into account in arriving at a final design.

Member: In the volume measurement of blast furnace gas, what does the operator do?

M. J. Boho: The question of blast furnace gas measurement involves both the means for measurement and the practical problem of maintaining the measuring element in a satisfactory state of cleanliness. Where dirty gas is burned, the use of burner pressures as an indication of flow rate has worked out quite satisfactorily. Where clean gas is burned, the usual methods using orifice plates, pitot tubes, etc., are as satisfactory with blast furnace gas as with the other fuel gases in the steel plant.

Burton D. Barnes: We have on the market oxygen analyzers. In talking in terms of mixed fuels, has there been any development in controlling air from, say, an oxygen analyzer?

M. J. Boho: The thought of using gas analysis as a control element for regulating combustion in boiler furnaces goes back a long time. While there is theoretical merit to the idea, practical factors have kept the system from enjoying widespread usage to date. Some of these practical factors include the difficulty of getting representative flue gas samples, the time delay element in the analysis of the sample, and the maintenance required to keep the mechanism in satisfactory operation. In the usual steel mill boiler plant, the extent and frequency of load changes is perhaps greater than in any other industry and, for this reason, any gas analysis control element should preferably be engineered into a control system in such a way that its effect is superimposed on a conventional design involving basic flow measurement and control of fuel and air. In this way, some of the above mentioned shortcomings can be circumvented.

CONTINUOUS CASCADE PICKLING

By

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and

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. . . . continuous cascade pickling has enabled greater flexibility, more uniformity, and higher speeds . . . .

▲ THE history and development of pickling techniques and equipment, theories of scale formation and theories of pickling action have been ably discussed by E. D. Martin, "Continuous Strip Pickling," Yearbook of the American Iron and Steel Institute, (1948), pp 602-653, and will not be covered here. However, very little has been written concerning the relative merits of continuous cascade pickling. Therefore, the scope of this paper will be to discuss one producer's experience with cascade pickling and to describe the equipment with which it is used.

In recent years, increased production costs and consumer demands have dictated the need for greater tonnages of cold reduced steel strip. As part of their program to keep abreast of these trends, the Jones & Laughlin Steel Corp. has installed a 42-in. continuous pickler at their Aliquippa works. This installation, which will be the chief topic of this paper, embodies the better features of earlier picklers together with some entirely new improvements to make it one of the most modern now in operation.

This pickle line is comprised of two major divisions, the entry and the delivery ends, separated by a looping pit. Included in the entry end, following the sequence of operation, are: coil conveyors, processor or scale breaker, upcut shear, welder, flash trimmer, stitcher and main pinch roll No. 1.

A system of conveyors transports hot band coils from the stocking floor to the processor. Here each coil is kicked onto an elevator that not only moves vertically but also travels horizontally between the conveyor and the processor. The coil may be revolved on the elevator by means of motor driven rolls, upon which it rests. These features of maneuverability permit rapid positioning of coils in the scale breaker.

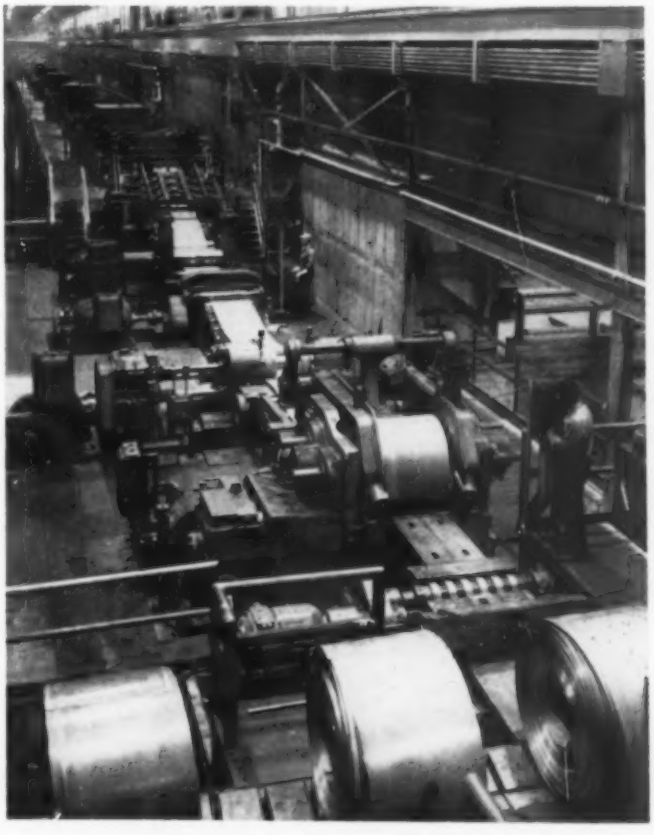
Two hydraulically operated small diameter flex rolls, each of which is backed up by a slightly larger roll, subject the strip to a reverse bending action causing a great number of very fine crossbreaks in the scale. This materially aids pickling by effecting some scale removal and by permitting better accessibility for the acid.

The expanding mandrel type uncoiler is equipped with a drag-generator motor that puts back tension, which is adjustable, into the strip. Also incorporated in this processor are two sets of driven pinch rolls followed by a roller leveller which serves to flatten the strip.

An upcut shear, equipped with air-operated side guides for positioning, properly cuts the strip for welding.

The successful operation of any continuous pickler is contingent upon the speed with which coil ends may be joined together. This line is equipped with both a

Figure 1 — The 42-in. continuous pickling line at the Aliquippa Works of Jones & Laughlin is operated at speeds up to 1500 fpm and arrangements are being made to increase this appreciably.



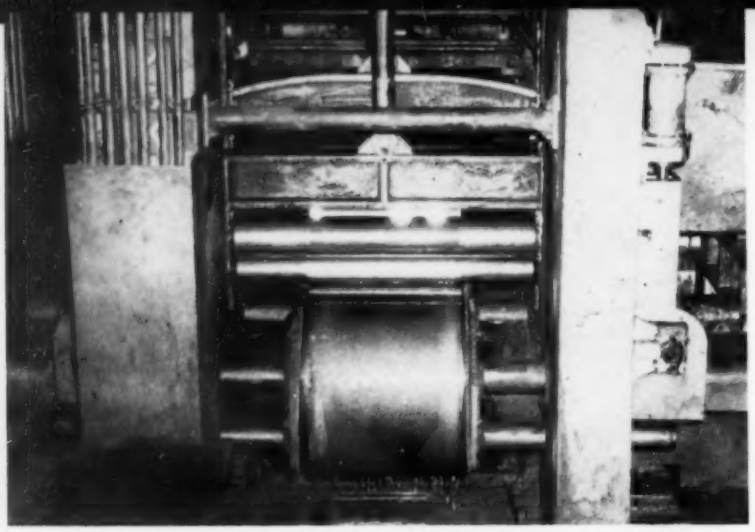


Figure 2 — The scale breaker consists of two small diameter rolls, each of which is backed up by a slightly larger roll.

conventional stitcher, which is only used as emergency stand-by equipment, and a flash buttwelder that has some unique features. The sequence of operations such as the clamping action, feed, push-up, welding and upset are all hydraulically operated and interlocked to function automatically. The following description of a normal welding cycle is presented to better identify the welder parts and describe their functions:

1. With the welder parts set for strip runout, the gage is up, the clamp is open, the movable head is back for gage clearance and the side guides are open. Settings have been made for welder heat, feed and gap.
2. The tail end of the leading strip is sheared square at the upcut shear. It is then advanced beyond the welder dies and stopped. The gage is lowered to the correct position. The tail end of the leading strip is backed against the gage head and a loop formed.
3. The leading end of the following strip is cut at the upcut shear to obtain sound strip for welding, after which it is advanced to the gage head. Additional material is fed by the processor. The looping roller is raised to provide extra strip for the moving dies; the processor is stopped, and the looping roller is lowered. There is then a loop which forces the strip end against the gage head and, since it is a free loop, the strip aligns itself against the head to establish the proper V-gap at the beginning of the flashing.
4. The side guards on both the stationary and the movable heads are closed by air to center the strip with the welder. (A motor is provided for shifting movement of the entry guide assembly, if required, after the side guards are closed.)
5. The upper heads are then lowered and the side guards opened. Operation of the switch, to clamp, energizes the main power cylinder solenoid, to clamp both strips in the dies, to admit air into the pullback cylinder for releasing the gage head, and to start the automatic welding cycle.
6. After a time delay (adjustable 0-3 seconds) following the operation of the switch for clamping, the gage raises automatically. At the top position of the gage, the power contactor closes, the main power cylinder feed solenoid is energized to admit air to both the main power feed cylinder and the gap take-up cylinder simultaneously, and the flashing cycle follows automatically. At the end of the flashing, the upset occurs almost instantaneously.
7. At the upset, the limit switch, through suitable adjustable time delay circuits opens the power contactor, unclamps the dies, resets the feed and after the strip has been released by the welder, starts the entry end to run at 200 fpm, until stopped by the operator.

Timing of the welding operation is performed by the metering valve. This valve controls the rate of fluid entry into the cylinder controlling the feed. The valve orifice is designed for giving a fairly uniform rate of advance for the movable die toward the stationary die during the first part of the feeding cycle, then the rate of feed increases to burn off the strip ends at a constantly accelerated rate until just before the upset. Then the valve opens fully to give unrestricted flow and the upset occurs almost instantaneously.

One of the more unique features of this welder is the power contactor. Instead of the conventional magnetic type contactor, it has an electronic type using two ignitrons to close and open the 440-volt main power circuit to the welder. Two sets of power tubes are included, but one is a spare available for immediate use in case of a breakdown. This feature also permits servicing, by qualified repairmen, any time they might elect, without delays on the line. A switch located on the welder desk permits the operator to select either contactor.

For heat selection, the welding transformers have separate primary and secondary windings. The primary winding has four taps for contactors which may be changed by a selector switch on the welder desk, instead of manually. Also the power tube contactor has voltage control by phase shifting, which is controlled from the welder desk. This gives a complete range of heats for the various steel widths and gages to be welded on this equipment.

After the weld has been made and moved to the flash trimmer, the strip is stopped by the operators with the weld under the trimming knives. The entire trimmer is designed to be moved, by motor drive, towards or away from the welder to aid in quickly spotting the weld directly between the cutter knives. The trimmer is equipped with a series of top and bottom knives which travel horizontally across the strip to trim the excess metal from the weld and make it the same thickness as the two adjacent areas. Following this operation the entire entry end, which also includes main pinch roll No. 1, is set in motion, and the strip is run into the looping pit where it folds into long loops. The maximum speed of the entry end is 1500 fpm, and it is currently being operated near that speed.

The looping pit is 42 ft long, 13 ft deep and is equipped with motor driven adjustable side guides, which allow a maximum width of 46 in. and a minimum width of 21½ in. The purpose of the looping pit is to provide storage for a sufficient length of strip that will permit

the entry end to stop and make welds without delaying the delivery end.

Included in the delivery end are the pickling tanks, rinse tanks and a dryer, which are located between main pinch rolls No. 2 and No. 3. No. 3 pinch roll is followed by an upcut shear, trimmer, oiler and upcoiler.

As the strip is being pulled from the looping pit by No. 2 pinch roll, it passes through adjustable side guides, which center the strip in the line, and a set of unfolding rolls that are located 22 ft above the floor of the looping pit, which distance aids in the loop unfolding operation.

There are four pickling tanks, all on the same level, constructed of $\frac{3}{8}$-in. steel, lined with $\frac{1}{4}$-in. rubber that is insulated with an eight inch double course brick lining, bonded together with acid proof cement. Each tank measures 80 ft long, 54 in. wide and 50 in. deep. Ten ceramic piers or skid blocks, each 8 in. high and 3 ft long, are imbedded in the brick floor of each tank and serve to hold the strip off the tank floor and to protect the four steam lines that are fastened along the floor. An offset is provided on both sides of each tank, at the center, which space provides protection to the two lead steam lines entering the tanks at the point.

A large rubber hold-down or dunking roll is located at the ends of each pickle tank. These rolls, which are operated by means of air cylinders and are designed with a tie between the end bearings to keep them parallel with the carryover rolls located between each tank, may be raised or lowered as desired, and serve to hold the strip down into the acid, thereby increasing if down or decreasing if up, the tank's effective pickling length. A set of rubber squeegee rolls, to control acid drag-out, is located at the exit end of the last pickle tank.

Dumping, for all solutions except the cold water spray rinse, is accomplished by drains equipped with a plunger type valve. Overflows are also an integral part of each drain.

Adjacent acid tanks are connected by an eight inch valve-controlled interconnect pipe. Valves are closed for operating tanks with batch type pickling, and opened, to permit solution flow from one tank to another with continuous cascade pickling. A combination of solution weight and level differences causes the solution to flow, in a counter direction to strip travel, from No. 4 tank, to which all continuous additions of inhibitor, acid and water are made, back through the other tanks to the point of discharge at the entry end of No. 1 tank.

Strip rinsing is accomplished in two tanks—a cold water rinse which contains six pairs of high-pressure sprays and a set of wringer rolls, followed by a hot water dip rinse which is equipped with stationary dunking rolls and a set of rubber wringer rolls at the exit end.

Rinse tanks are of the same construction as the acid tanks, and all are equipped with rubber-lined covers. Large rubber-lined ducts are attached to each tank and are connected to a fume control exhaust system. Two 30,000 cfm exhaust fans maintain a negative pressure in the ducts to draw pickling fumes and steam through a central vapor washer.

Solutions are heated by steam emitted through jets contained in and spaced along the horizontal length of each of the four steam lines mentioned above. Two heaters, one on each side, are located in each end of each tank. The design of the piping arrangement and valves to these heaters affords considerable flexibility of operation to insure maximum efficiency. Steam in two of the heaters, situated at diagonally opposite ends of each tank, is controlled manually to provide auxiliary heat and bath agitation, thereby keeping fresh solution in contact with the strip. The remaining two heaters are individually and automatically controlled by motor operated valves, which in turn are controlled by recording type thermostatic regulators. They are also piped to bypass the thermostatic controllers and thus be operated manually. Solution temperatures are currently maintained at 210 F.

In addition to the above solution heating equipment, each tank is equipped with a steam injector mixing valve which permits the addition of heated water for new solution makeup.

All acid handling equipment, except for lead piping into pickling tanks, is made of plain unlined steel. Five 20,000 gal tanks are used to store acid which is transported to the plant in river barges, each of which has a capacity of approximately 100,000 gal.

Acid may be added in any one of three ways on this line. The first, with which all are familiar, is the conventional method of opening a valve and estimating the amount of acid added. The second, which can be used for new tank makeup or spot additions in batch pickling, employs a solenoid operated valve controlled by an impulse counter; one impulse on this counter is equivalent to 310 lb of 66 degree Baumé sulphuric acid. The arrangement functions in the following manner: the operator opens the acid valve at the tank to which he desires to add acid, adjusts the dial impulse indicator to the required number of impulses, and presses a button which energizes the equipment. The instrument allows the predetermined amount of acid to flow into the tank and then automatically shuts off the flow. The number of impulses are accumulated on a counter, so that the amount of acid used during the turn is available to the operator and the accounting department.

Figure 3 — Many unique features are incorporated in the welder for the 42-in. continuous pickling line.

TABLE I

42-In. Continuous Pickler

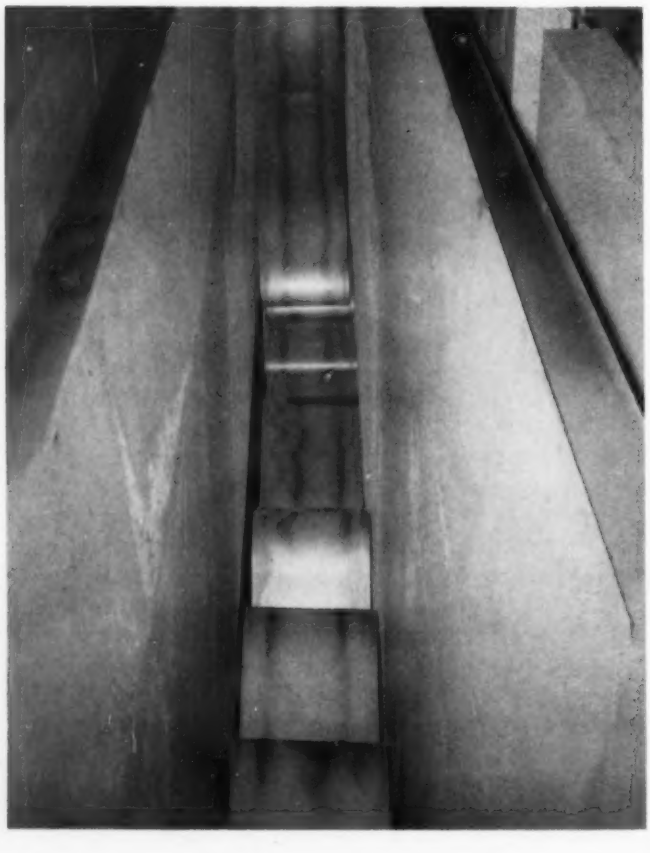
Acid and Inhibitor Additions

Based on Addition of 35 Lb of 66° Bé H_2SO_4 per Ton

Tons per hr	Lb of acid per min	Inhibitor		Lb of water to make the following acidities, per cent				
		Pints per hr	Cc's per min	15	18	20	25	30
40	23	2.7	21	120	96	84	63	48
45	26	3.0	24	135	108	95	71	55
50	29	3.4	27	151	121	106	79	61
55	32	3.8	30	167	133	117	87	67
60	35	4.1	32	182	146	128	95	74
65	38	4.5	35	198	159	139	104	80
70	41	4.8	38	214	171	150	112	86
75	44	5.2	41	229	184	161	120	93
80	47	5.5	43	245	196	172	128	99
85	50	5.9	46	261	209	183	136	105
90	53	6.2	49	276	221	194	145	112
95	55	6.5	51	287	230	201	150	116
100	58	6.7	54	302	242	212	158	122
105	61	7.2	57	318	254	223	166	128
110	64	7.5	59	333	267	234	174	135
115	67	7.9	62	349	280	245	183	141
120	70	8.2	65	365	292	256	191	147

The third method, which controls the continuous additions of acid and water and is used with cascade pickling, consists of two proportioning flowrators—one for acid and one for water, solenoid valves, energizing equipment, ratio adjustor, totalizers and integrators. The flowrators are calibrated in terms of pounds per minute of acid and water.

Figure 4 — The looping pit is 42 ft long and 13 ft deep.



Before operating this equipment, it is first necessary to know the correct amount of acid and water to be added and the number of tons being pickled per hour. The acid and water requirements are determined by referring the tons per hour being pickled to a prepared chart (see Table I) which is calculated on the basis of using 35 lb of 66° Baumé sulphuric acid for each ton of steel pickled. Percentages are calculated on a weight basis. The chart shows tonnages from 40 tons per hour and up, giving the correct amount of inhibitor to add, and the required amounts of acid and water to obtain 15, 18, 20, 25 or 30 per cent acid solutions in No. 4 tank.

To operate the equipment the water valve is opened and regulated to allow the desired number of pounds per minute of water to pass through the water flowrator. The instrument ratio adjustment dial is set at the desired percentage of acid and the equipment energized. Then the control instrument takes over and automatically adds the correct amount of acid. While in operation, the amounts of water and acid used are traced on a calibrated 24-hr chart and the amount of acid used is also accumulated on two accumulating totalizers, one of which may be reset at the beginning of each turn.

It was previously mentioned that this line is equipped to operate using either batch or cascade type solution control. When the line first started, it was operated seven months using batch type, and since that time has used the cascade type almost exclusively.

With batch type control each tank was made up with 8400 gal of solution that was approximately 20 per cent by weight of pure sulphuric acid. Periodically, additional acid was added, to maintain this percentage, until the iron content of the solution reached 5 to 6 per cent by weight of pure iron. (All solution concentration percentages used in this paper are actual per cent by weight of pure acid and pure iron.) At this point, tanks were allowed to work down until the acid reached 9-10 per cent and the iron increased to 7-9 per cent, at

TABLE II

Batch Pickling

Average Solution Concentration of Pickling Tanks

and Acid Consumption by Months

Month	Tank No. 1		Tank No. 2		Tank No. 3		Tank No. 4		Acid consumption lb per ton
	Per cent acid	Per cent iron	Per cent acid	Per cent iron	Per cent acid	Per cent iron	Per cent acid	Per cent iron	
January 1948	10.8	4.5	13.1	6.4	14.9	5.3	19.2	3.5	35.2
February 1948	8.4	5.8	12.3	5.5	15.0	5.9	19.0	3.9	29.7
March 1948	11.1	5.4	13.7	5.8	16.7	6.4	18.2	5.1	33.1
April 1948	13.7	5.5	14.9	5.3	18.4	4.4	19.8	5.3	37.2
May 1948	13.9	4.6	16.9	5.6	18.4	5.6	18.5	5.2	37.7
June 1948	13.4	4.4	16.4	5.1	17.3	5.1	16.9	3.9	40.6
July 1948	12.7	4.4	16.6	5.3	16.1	5.2	15.4	4.0	30.9
Average	12.0	4.9	14.8	5.6	16.7	5.4	18.2	4.4	33.9

which time the tank was dumped and a fresh solution made up. Table II lists, by tanks, the average acid and iron concentration maintained for each month of batch pickling.

During the period this line operated with batch type solution control, the average acid consumption was 33.9 lb per ton of steel pickled, which is considered a good figure. Also, during that time, 125 tanks of spent solution were dumped and new solutions made up. The average concentration of these tanks, when dumped, was 10.7 per cent acid and 8.2 per cent iron. Tank numbers 2, 1, 3 and 4 were changed most frequently, in that order.

With batch pickling, iron sulphate crystals would frequently build up on the bottoms of tanks in large quantities. This would necessitate removing tank covers while the deposit was being washed out. A few times, when the deposit became encrusted with crystals of the heptahydrate form, it required prying and digging to loosen them. On one occasion, a drain valve assembly had to be taken apart to remove the crystals.

In order to do a good job of pickling while replenishing spent solutions, line speeds were usually reduced with a resultant loss of production.

With cascade type solution control, as practiced on this line, all acid, water and inhibitor additions are made continuously to No. 4 tank. The solution then flows back through the other tanks, by way of the interconnects, to No. 1 tank from where it is dumped.

When cascade pickling was first used, No. 4 tank was maintained at the same or a higher acid concentration, than was used in batch pickling. However, time and experience have demonstrated that this is not necessary, so that currently only 16 to 18 per cent acid is being added to No. 4 tank.

The most outstanding feature of cascade solution control is the high degree of uniformity that can be maintained from day to day and month to month. This is illustrated in Table III which shows the average acid and iron concentrations for each tank for each month this line has operated with cascade pickling. Also shown are the average acid consumption figures for

TABLE III

Cascade Pickling

Average Solution Concentration of Pickling Tanks

and Acid Consumption by Months

Month	Tank No. 1		Tank No. 2		Tank No. 3		Tank No. 4		Acid consumption lb per ton
	Per cent acid	Per cent iron	Per cent acid	Per cent iron	Per cent acid	Per cent iron	Per cent acid	Per cent iron	
August 1948	7.2	6.3	11.4	5.9	17.0	3.3	20.8	1.1	38.7
September 1948	8.9	5.6	12.7	5.9	18.0	3.5	22.8	1.4	32.7
October 1948	9.4	5.4	14.4	5.6	20.9	3.4	25.3	1.4	33.7
November 1948	9.5	5.3	15.0	5.1	21.1	2.6	24.4	.9	33.5
December 1948	6.8	4.4	10.6	4.4	14.9	2.6	17.7	1.0	31.2
January 1949	6.8	4.4	10.2	4.3	13.9	2.7	16.5	1.0	29.1
February 1949	4.6	3.6	9.8	4.8	13.8	3.1	17.5	1.1	34.0
March 1949	6.3	4.6	9.3	4.7	12.9	3.1	16.3	1.1	30.7
April 1949	6.8	4.8	9.8	5.0	13.8	3.4	18.2	1.4	35.6
May 1949	6.1	6.5	9.2	4.6	12.9	3.1	16.8	1.2	33.7
June 1949	5.4	3.9	9.4	5.0	13.2	3.4	17.4	1.2	37.0
July 1949	4.2	2.7	10.2	4.7	13.3	3.1	17.0	1.1	40.2
August 1949	3.7	3.1	11.3	4.0	14.6	2.7	17.7	1.0	41.0
September 1949	7.2	4.7	10.2	4.6	13.6	3.1	17.1	1.2	34.8
November 1949	8.3	3.7	11.3	3.9	14.1	2.5	17.8	.9	41.0
December 1949	7.6	4.7	10.6	4.9	13.2	3.8	16.8	1.6	34.7
Average	6.8	4.6	10.9	4.8	15.1	3.1	18.7	1.2	34.8

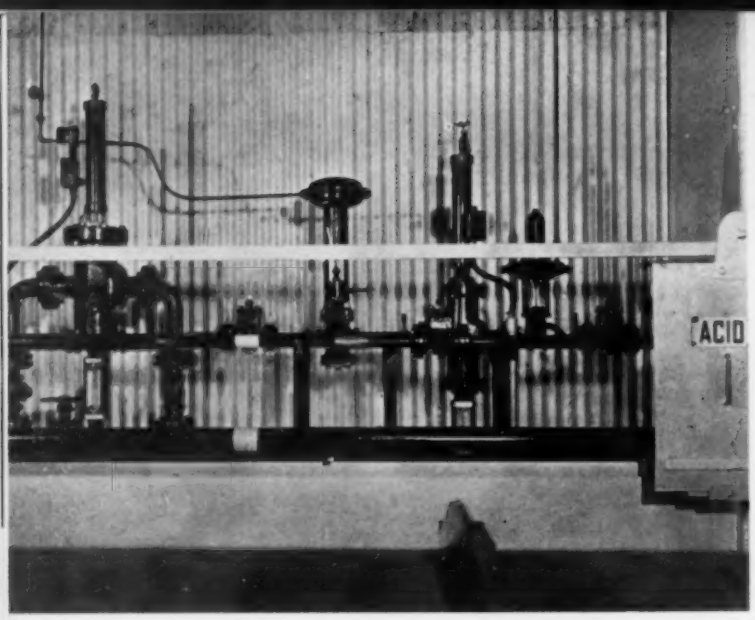


Figure 5 — Acid may be added to the line in any one of three ways. Shown in the illustration is the continuous acid addition equipment.

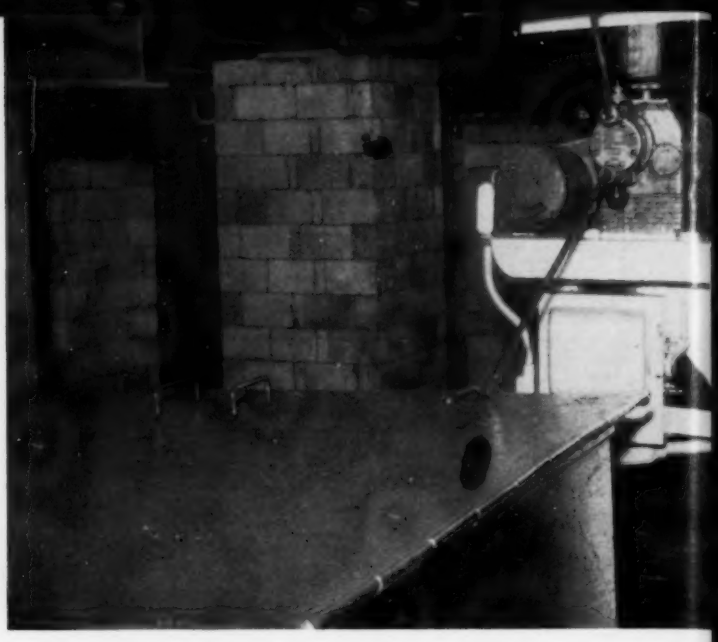


Figure 6 — Inhibitor is added continuously to the line at No. 4 tank.

each month. The average acid consumption for sixteen months' operation was 34.8 lb per ton. Although this figure is 0.9 lb per ton higher than obtained with batch pickling, it is still considered good.

Another feature of cascade pickling is the flexibility it offers for pickling various grades of steel. It permits maintaining acid concentrations on the low side, near the minimum requirements, from which point solution pickling rates may be quickly increased or decreased as desired. When pickling bessemer steel or added phosphorus open hearth grades of steel, the practice is to decrease solution agitation and temperature. Also, if necessary, one or more dunking rolls may be raised to decrease the effective pickling length of the tanks.

Other attractive features of the cascade system are the simplicity with which the acid addition equipment may be operated and the minimum amount of attention required to maintain uniform solutions. Standard practice is to test solutions once every four hours.

Experiences, as just related, indicate that the cascade type of pickling is superior to the batch method for the following reasons:

1. Requires no dumping of tanks, except in cases of emergency, thus eliminating tonnage loss due to pickling with three tanks while the fourth is being drained and refilled.
2. A more uniformly pickled strip is obtained from coil to coil, since the occasion never arises where two tanks are working down at the same time.
3. Iron sulphate does not build up to the point of saturation where crystals precipitate out of solution to accumulate on the tank floor.
4. Pickling tanks are always at a relatively high operating efficiency.
5. In general, cascade type pickling has permitted faster average pickling speeds.

It is well known that the character of the scale formation on hot rolled strip in coil form is not uniform, which may lead to variable scale removal rates, and perhaps overpickling, in uninhibited acid baths. The presence of an inhibitor will prevent severe acid attack on any unscaled metal and leave more acid available for scale removal, thus reducing the over-all amount of acid consumed in the pickling operation. On this line an unusual method for adding inhibitor is employed in conjunction with cascade pickling. A specially prepared grade of liquid inhibitor is added continuously through a proportioning chemical feed pump. This is a positive action diaphragm pump which the operator adjusts, by lengthening or shortening the stroke, to add the desired number of milliliters of inhibitor per minute. Additions are based on a consumption of three-eighths of one per cent of inhibitor for the volume of sulphuric acid used.

The remainder of the delivery end of this line is of conventional design and includes: a hot air dryer, No. 3 pinch roll, an upcut shear, rotary side trimmer, oiler and upcoiler. The maximum speed of the delivery end is 650 fpm and it is currently being operated between 450 and 500 fpm.

With the over-all length of the line being approximately 592 ft, it can be appreciated that the electrical features, necessary to synchronize several units under one control are quite complicated and warrant a separate discussion. Although a detailed discussion is not planned here, a brief resume will be given of some features to demonstrate the flexibility of operations provided.

Both the delivery and entry ends of the line have a main control board from which all the driving motors of the various units, contained in that part of the line, may be operated simultaneously. Also, there are controls at each unit for operating that unit individually. This arrangement allows the welder operator to position the back end of one coil in the welder while a coil is being placed in the processor, the front end sheared or squared and then moved up to the welder.

At the delivery end, when the coil in the upcoiler has reached the desired size, the operator may stop the strip, set the shear in motion and after the strip has been cut in two, the upcoiler and slitter will start automatically and trim and recoil the remainder of the coil at running speed. During this time the operator may start the remainder of the delivery end on slow run and

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by the time the previous coil has been ejected, the front end of the next coil is entering the upcoiler.

In addition to the aforementioned controls, there are jog switches at each individual unit, together with emergency stop buttons which will immediately stop all the units contained in the same part of the line.

The entry and delivery ends have no common controls except the entry end has an off-and-on switch which will stop the entire delivery end. This is used only when the delivery end is getting ahead of the entry end and there is danger of emptying the looping pit of strip.

Although this line is considered modern, and one of the fastest now in operation, plans are currently being formulated to increase the speed of the entry end to 2000 fpm. The design of future pickle lines to give higher speeds and greater tonnages will pose many engineering problems.

In conclusion, the following is a brief summary of the more important features and experiences associated with this line:

1. The scale breaker has an expanding mandrel type uncoiler that is equipped with a drag generator motor to give variable tension. Hydraulically operated flexrolls serve to break the scale.
2. The sequence of welding operations are hydraulically operated and interlocked to function automatically. Electronic ignitron tubes are used for welder power contactors.
3. There are four eighty-foot pickling tanks, all on the same level, equipped with hold-down rolls.
4. This line is equipped for operating with either batch type or continuous cascade pickling. Separate instruments are provided for measuring acid additions for both types of solution control. The cascade system operates continuously to add the correct amounts of acid and water to No. 4 tank.
5. Reduced production attributed to iron sulphate buildup in solutions, was experienced when operating this line with batch type pickling.
6. Continuous cascade pickling has been very successfully employed in operating this line. The continuous addition of acid holds solutions within desired concentration limits from day to day. Iron sulphate does not build up to an objectionable point. Greater flexibility is provided for pickling different grades of steel. More uniformity is possible when pickling the same grade of steel. Continuous cascade pickling has also permitted faster average pickling speeds.

AISE COOPERATES IN PITTSBURGH INSTRUMENT CONFERENCE

▲ THE Pittsburgh Section of the Instrument Society of America and the Carnegie Institute of Technology are cosponsoring a conference on "Instrumentation in the Steel Industry." The Pittsburgh Sections of the following national societies are cooperating: American Institute of Electrical Engineers, American Institute of Mining & Metallurgical Engineers, Association of Iron and Steel Engineers, American Society for Metals, American Society of Mechanical Engineers, American Society for Testing Materials, American Welding Society, and the Engineers Society of Western Pennsylvania. The meetings will be held March 28 and 29 at the Roosevelt Hotel in Pittsburgh.

The program for this conference includes:

"Electric Servo Mechanisms"
by Elwood T. Davis
Leeds & Northrup Co.

"Hydraulic Controls"
by H. Ziebolz
Askania Regulator Co.

"Pneumatic Controls"
by A. A. Markson
Hagan Corp.

"Comparison of Methods of Measuring Molten Metal Temperatures"
by J. W. Percy
U. S. Steel Co.

"Instrumentation in Controlling the Welding Variable"
by Julius Heuschkel
Westinghouse Electric Corp.

"Instrumentation and Control in the Utilization of Mixed Fuels and Oxygen in Open Hearth Furnaces"
by Martin J. Conway, Consulting Engineer
and
Edward H. Cauger
Wheeling Steel Corp.

"High-Speed Reheating of Seamless Steel Tubes"
by H. W. Cox
National Tube Co.

"Methods for Sorting Mixed Metals"
by Anthony Doschek
Doschek Associates

"A Thermal Couple System for Molten Metal Temperature Measurement"
by Lester Veiock
Heppenstall Co.

"The Industrial Application of the X-Ray to the Inspection of Steel Castings"
by J. N. Flanagan
Pittsburgh Ordnance District
Ordnance Corps.
U. S. Army

CURRENT AISE DISTRICT SECTION MEETING NOTICES

BIRMINGHAM SECTION

Monday, March 26, 1951 — Dinner 6:30 P.M., Meeting 8:00 P.M.

"Production of Metallurgical Coke" by D. D. Cox, Superintendent of By-Product Department, Tennessee Coal, Iron & Railroad Co., Fairfield, Ala.

Thomas Jefferson Hotel, Birmingham, Ala.

▲

BUFFALO SECTION

Tuesday, March 13, 1951 — Dinner 6:30 P.M., Meeting 8:00 P.M.

"Recent Developments in Open Hearth Combustion" by H. H. Northrup, Superintendent Open Hearth, Republic Steel Corp., Buffalo, N. Y.

"Open Hearth Practices at the Lackawanna Plant" by F. G. Gregory, Superintendent of Open Hearth No. 3, Bethlehem Steel Co., Lackawanna, N. Y.

Sheraton Hotel, 715 Delaware Ave., Buffalo, N. Y.

▲

CHICAGO SECTION

Tuesday, March 6, 1951 — Dinner 6:15 P.M., Meeting 7:45 P.M.

SYMPOSIUM "Fuels and Furnaces" Symposium Leader — A. A. Fennell, Chicago District Manager, Bloom Engineering Co., Chicago, Ill.

Phil Smidt's Restaurant, 1205 Calumet Ave., Hammond, Ind.

▲

CLEVELAND SECTION

Monday, March 19, 1951 at Cleveland, Ohio — Dinner, 6:30 P.M., Meeting 8:00 P.M.

Tuesday, March 20, 1951 at Youngstown, Ohio — Dinner, 6:30 P.M., Meeting 8:00 P.M.

"The Water Pollution Control Program of Ohio" by B. M. McDill, Engineer in Charge of Water Pollution Control, State Department of Health, Division of Sanitary Engineering, Columbus, Ohio.

Cleveland: Cleveland Engineering Society, 2136 E. 19th St., Cleveland, Ohio.

Youngstown: El Rio Club, Youngstown-Warren Rd., Route 422, Youngstown, Ohio.

▲

DETROIT SECTION

Tuesday, March 13, 1951 — Dinner 6:30 P.M., Meeting 8:00 P.M.

"Electronic Equipment for the Steel Industry" by H. W. Poole, Manager, Steel Mill Division, Industrial Engineering Division, General Electric Co., Schenectady, N. Y.

Detroit Sales Auditorium, Detroit, Mich.

▲

PHILADELPHIA SECTION

Saturday, March 3, 1951 — Dinner 6:00 P.M., Meeting 7:00 P.M.

"The Function of Lubricating Engineers in the Steel Industry" by C. R. Hand, Assistant Superintendent, Mechanical Department, Bethlehem Steel Co., Sparrows Point, Md.

"Recent Lubricating Problems at Sparrows Point" by A. E. Cichelli, Lubricating Engineer, Bethlehem Steel Co., Sparrows Point, Md.

Engineers' Club, 1317 Spruce St., Philadelphia, Pa.

▲

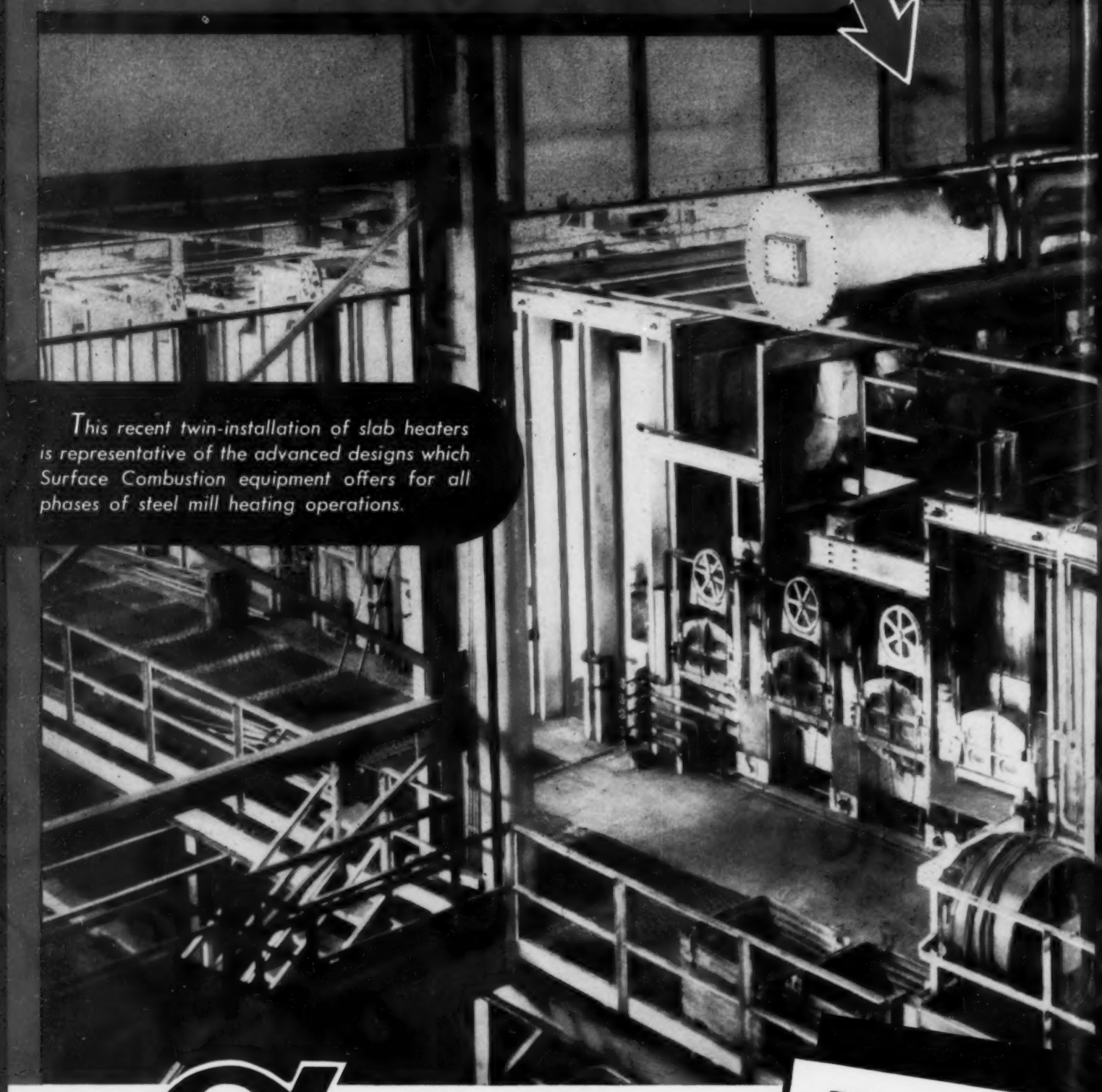
PITTSBURGH SECTION

March 12, 1951 — Dinner 7:00 P.M., Meeting 8:00 P.M.

"Steel Plant Dust Control Through Ultrasonics" by C. Richard Soderburg, Jr., Chief Engineer, Ultrasonic Corporation, Cambridge, Mass.

University Club, University Place, Pittsburgh, Pa.

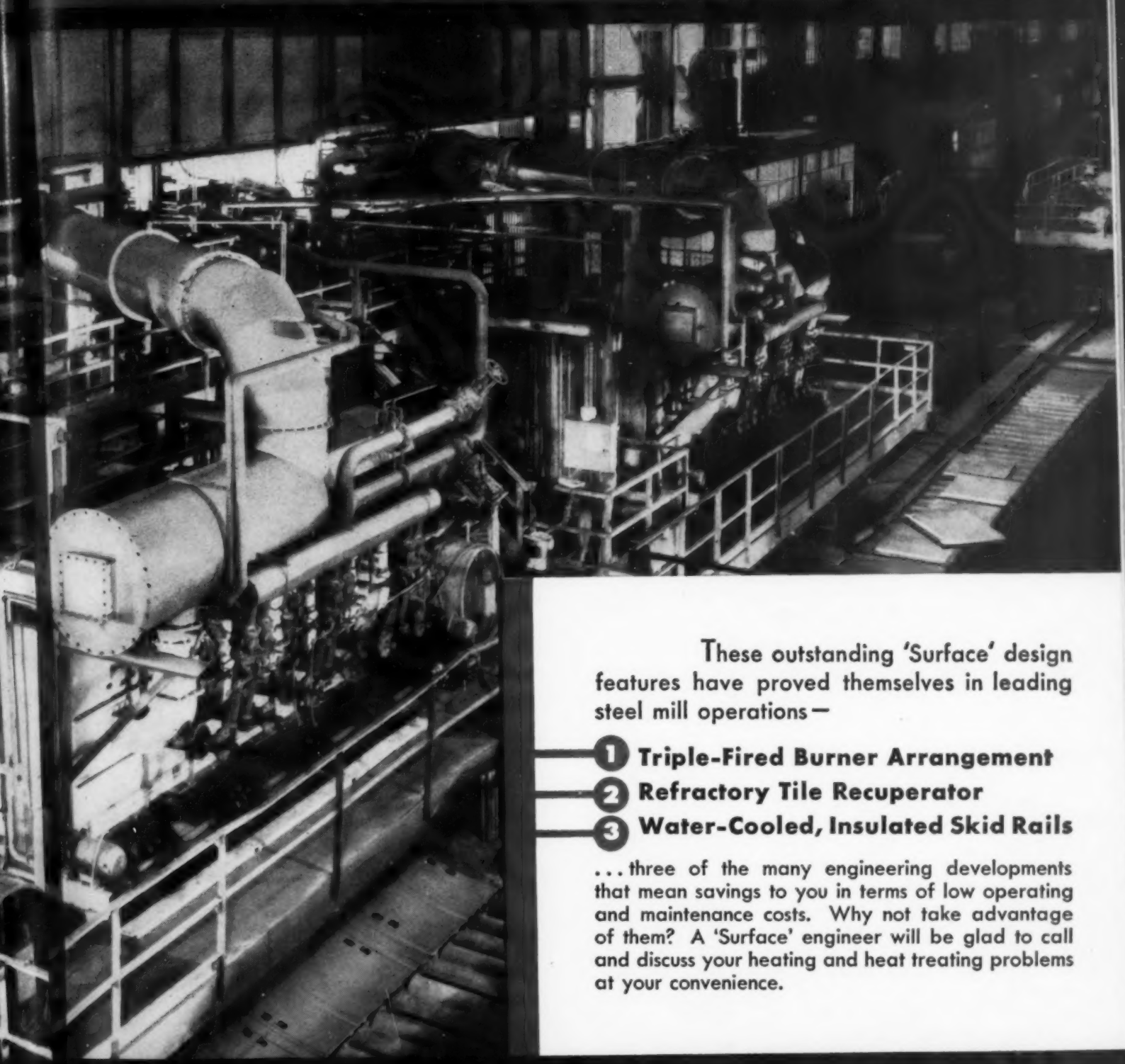
One of the Latest 'Surface'



This recent twin-installation of slab heaters is representative of the advanced designs which Surface Combustion equipment offers for all phases of steel mill heating operations.

'Surface' SERVES THE STEEL INDUSTRY

Triple-Fired Slab Heater Installations



These outstanding 'Surface' design features have proved themselves in leading steel mill operations—

1. **Triple-Fired Burner Arrangement**
2. **Refractory Tile Recuperator**
3. **Water-Cooled, Insulated Skid Rails**

...three of the many engineering developments that mean savings to you in terms of low operating and maintenance costs. Why not take advantage of them? A 'Surface' engineer will be glad to call and discuss your heating and heat treating problems at your convenience.

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Continuous Type, Controlled Atmosphere Strip Annealing and Normalizing Furnaces

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Controlled Atmosphere Annealing Covers for Coil and Sheets

Continuous Furnaces for Heat Treatment of Steel Plate

Controlled Atmosphere Furnaces for Carbon Correction in High Alloy Rod and Bar Stock

Continuous Type Bright Annealing and Normalizing Furnaces

Prepared Gas Atmosphere Generating Equipment

Pit Type Convection Furnaces for Rod Annealing

Stress Relief Furnaces

Wire Patenting Furnaces

INLAND INSTALLS NEW COAL PREPARATION PLANT

▲ The placing in operation of its new coal preparation plant at Price, Ky., enables Inland Steel Co. to reduce the cost and to increase the production of pig iron without the erection of new steel-making facilities.

It is estimated that the new coal cleaning plant will make possible a reduction in the ash content of Inland's metallurgical coal to 3.5 from 7 per cent. Using the industry's rule-of-thumb that each 1 per cent of ash reduction is equal to 30 cents in the cost of pig iron, Inland's cost per ton of producing pig iron is expected to drop more than a dollar per ton.

Because the coal cleaned by the new plant will contain an appreciably lower percentage of ash, slag volume produced in the blast furnace will be reduced about 10 per cent. Experience has shown that such a decrease in slag volume is accompanied by a decrease of 4 per cent in coke consumption per ton of iron, and an increase of 4 per cent in iron production.

Inland's coking coal from eastern Kentucky is inherently low in ash. Old hand loading mining methods produced a coal with approximately 5.1 per cent ash, whereas coking coal is commonly used by other steel producers with from 7 to 8 per cent ash. By the introduction of modern coal cleaning methods, Inland has further reduced this low ash-content of its coal, and thus increased pig iron production.

The new plant, which has been called "the most completely engineered in the country," contains the most advanced equipment for the efficient preparation of run-of-mine bituminous coal for metallurgical use. Designed and built by Link-Belt Co., the plant has a capacity of 750 tons of raw coal an hour. Slate, rock, fire clay and other impurities are mechanically removed. An elaborate system of blending bins, paddle mills, and conveyor systems permit the automatic mixing of sizes and analyses for delivery direct to railroad cars.

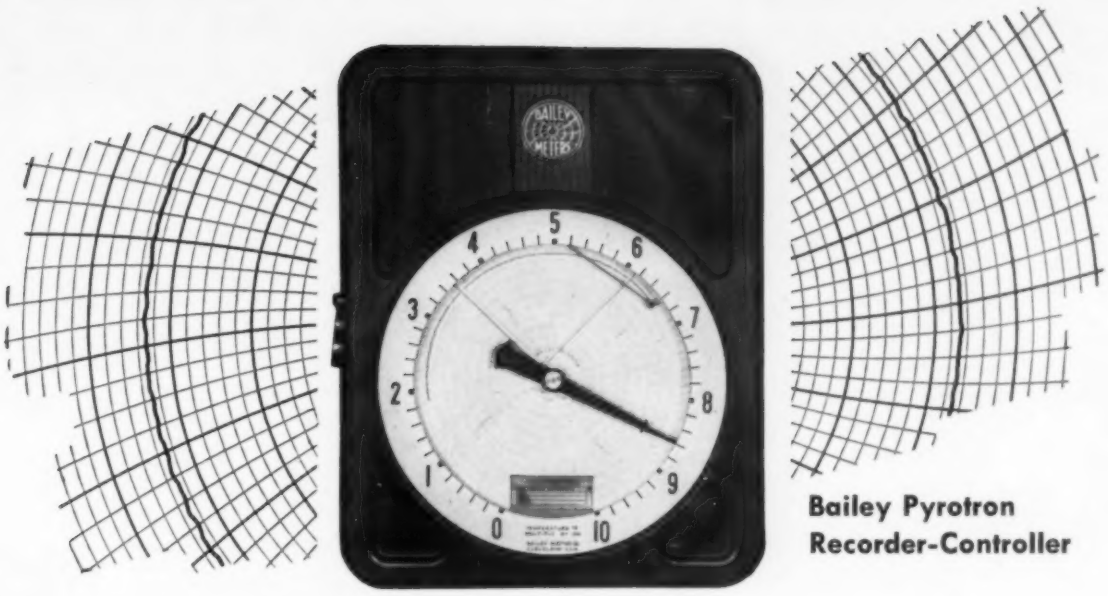
Moreover, the new plant enables Inland to engage in "total seam" mining, and by extracting coal in fault areas which could not previously be mined at favorable costs, Inland not only is increasing ton-per-man production of coal, but is recovering a larger percentage of the total coal deposit before withdrawing from an area.

PIG IRON PRODUCTION

The coal washing plant is expected to reduce the ash content of the coal from 7 to 3.5 per cent. As a result, these important advantages will follow as the resultant low-ash coke is used in blast furnaces in the manufacture of pig iron:

1. Freight Saving. Ash is ballast that has to be carried through the process and acts as a detriment to the efficiency of operations.
2. Thirty per cent decrease in coke ash. Ash in the coke will be reduced from 9 to 6.5 per cent.
3. By-Product production up. The use of the cleaner coal in the coal blend will give percentage increases in by-product production per day as follows:
   Ammonium sulphate..... 10
   Coal tar..... 5
   Light oil (benzol, toluol, xylol)..... 5
   Coke oven gas..... 2
4. Blast furnace operation improved. Slag volume, due to less ash and consequently less limestone, is expected to drop about 10 per cent.

Figure 1 — Raw coal, fed into the plant from the headhouse, seen in the lower left corner, at a rate of 750 tons an hour, never stops moving until it reaches the railroad cars in the valley, after the sorting, crushing, washing and blending sequence. All mine rock and ash-forming impurities removed are conveyed up the hillside in the right background to a refuse disposal bin, from which they are trucked away.



Bailey Pyrotron
Recorder-Controller

Looking for Better Temperature Instruments?

...Then check these features of Pyrotron Electronic Resistance Thermometers...

FUNDAMENTAL ACCURACY

Bailey Pyrotron Resistance Elements are made of highest purity platinum—the material used by the National Bureau of Standards in establishing basic standards for temperatures from −190°C to +660°C.

THREE TYPES OF CONTROL

Pyrotron Controllers may operate: on-off electrical systems by either electronic relays or electric contacts, modulated electronic systems, or air-operated systems. Two temperatures may be recorded on the same chart and controlled by a single instrument.

FACTS PUT INTO USABLE FORM

Bailey Pyrotrons may be arranged to put temperature facts into convenient usable forms. If two or more temperatures are related, they may be recorded as continuous records on the same chart for easy comparison. The average of several temperatures or the difference between two temperatures may be recorded as a single continuous record which may be retransmitted to a distant point or used to actuate a control system.

EASY INSTALLATION

Bailey Pyrotrons do not require careful leveling or protection against vibration. Three ordinary copper wires are all that is needed to connect each temperature sensitive element with the recorder. Power may be taken from any 115 volt 60 cycle circuit.

MINIMUM MAINTENANCE

The absence of galvanometers, batteries and standardizing equipment, together with the use of interchangeable unit assemblies, reduces Pyrotron maintenance to the vanishing point.

ABUNDANT POWER

A separate motor drive for each temperature furnishes abundant power to operate a recording pen, a controller and an alarm switch.

For the full story on this unusual electronic resistance thermometer which is suitable for ranges between −300°F and 1200°F, ask for Bulletin No. 230-C. P-21

BAILEY METER COMPANY

1047 IVANHOE ROAD • • • CLEVELAND 10, OHIO

Controls for Processing

TEMPERATURE	FLOW
PRESSURE	LEVEL
% OXYGEN	DENSITY
% COMBUSTION	RATIO

5. Iron production increased. The decrease in slag volume is expected to decrease coke consumption 4 per cent and increase iron production 4 per cent.
6. Open hearth capacity increased. Increased production of molten iron will decrease the time necessary for completing a heat in the open hearth.

IMPROVED MECHANICAL MINING

The development of improved coal preparation methods and equipment, the latest of which are incorporated at Inland's Price, Ky., plant, has been hand-in-hand with the development of mechanical underground mining methods.

Since the machine loader cannot separate and pick out the slate, the impurities in the coal as it comes to the surface increase materially with mechanical loading. The solution is the designing and construction of more accurate and complete preparation facilities which permit total seam mining.

Accordingly, plans for the construction of a new central coal preparation plant began to take shape in 1946 after Inland had increased its holdings in the Elkhorn No. 3 Seam to approximately 30,000 acres by the purchase of an additional 10,700 acres.

To reach the new preparation plant, it was necessary to build a 4½-mile haulage tunnel to connect the Wheelwright mine with the Price mine and the preparation plant. Consideration was given to both track and belt haulage, but track haulage from an assembly yard underground was finally decided upon.

DESIGN OF NEW PLANT

The design of the new coal preparation plant was preceded by a series of carbonization tests and the assembly of all necessary basic engineering data. As a result, facilities have been provided to handle all of the coal Inland produces at its own mines, as well as the "foreign" coal Inland purchases from other producers in the Elkhorn field. The plant is designed to handle and prepare run-of-mine bituminous, containing lumps up to 24 × 24 × 24 in. in size, at the rate of 750 tons-per-hour. This coal will all be received through the west portal of the company's mine at Price, or by railroad or truck. The Chesapeake and Ohio Railway Co. has established milling-in-transit rates under which coal will move to the plant for beneficiation.

The new plant is modern in every respect, and has been designed to take care of every contingency that may arise in the foreseeable future. For example, provision is made to permit future installation of an east headhouse at a later date.

Briefly stated, the plant is prepared to load out into railroad cars:

1. Plus 5 in. lump.
2. 5 × 3 in. egg.
3. 1¼ × ⅜ in. stoker.
4. 2 × 0 in. slack; to which may be added, after crushing to approximately 1½ in. ring size, all or part of the stoker, or all or part of the lump, or all or part of the egg.

Inland has always sold a large tonnage of domestic coal. For that reason, the lump (plus 5 in.) will not be passed through the wash boxes. Surplus lump will be crushed and mixed with the metallurgical coal.

The plant is equipped with Link-Belt Model 6044-E air pulsated wash boxes for cleaning 5 × ⅜ in. coal, and Deister diagonal deck washing tables for cleaning ⅜ × 0 in. coal.

It was decided for economic as well as technical reasons to reduce moisture in the washed coal mechanically rather than by thermal drying. Therefore, Bird centrifugal filters are used to dewater the washed ⅜ × 0 in. coal, and dewatering screens are used for the 5 × ⅜ in. coal.

The mechanical handling of locally mined coal starts at the Price Mine headhouse high on the mountainside, with a mine car-feeder ahead of a two-car rotary dump. This feeder is designed to handle a trip of 75 loaded 3-ton capacity mine cars, of which not more than 20 will contain mine rock. As the cars are advanced by the dump operator, they are weighed at the track scale and then dumped two at a time without uncoupling. Motor-operated gates under the dumper enable the load to be dumped directly either to the coal hopper or to the rock hopper without regard to the position of the car in the trip, and without delay in the dumping cycle.

Mine rock delivered from mine cars or hand-picked from the lump coal is fed by reciprocating feeder from the rock dump hopper to a belt conveyor which discharges it to a crusher for reduction to about minus 6 in. Belt conveyors lower the crushed rock down the mountainside to the valley, where the preparation plant is located, then across the valley where rejects from the coal washery join it, and up the opposite mountainside to a bin for disposal in a gob pile by truck or bulldozer.

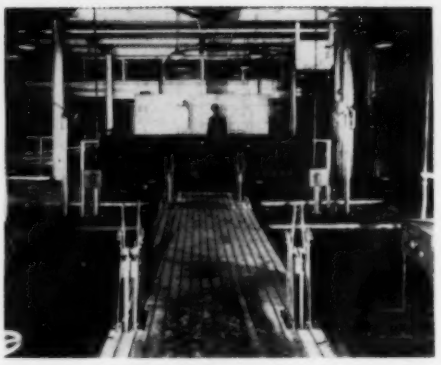
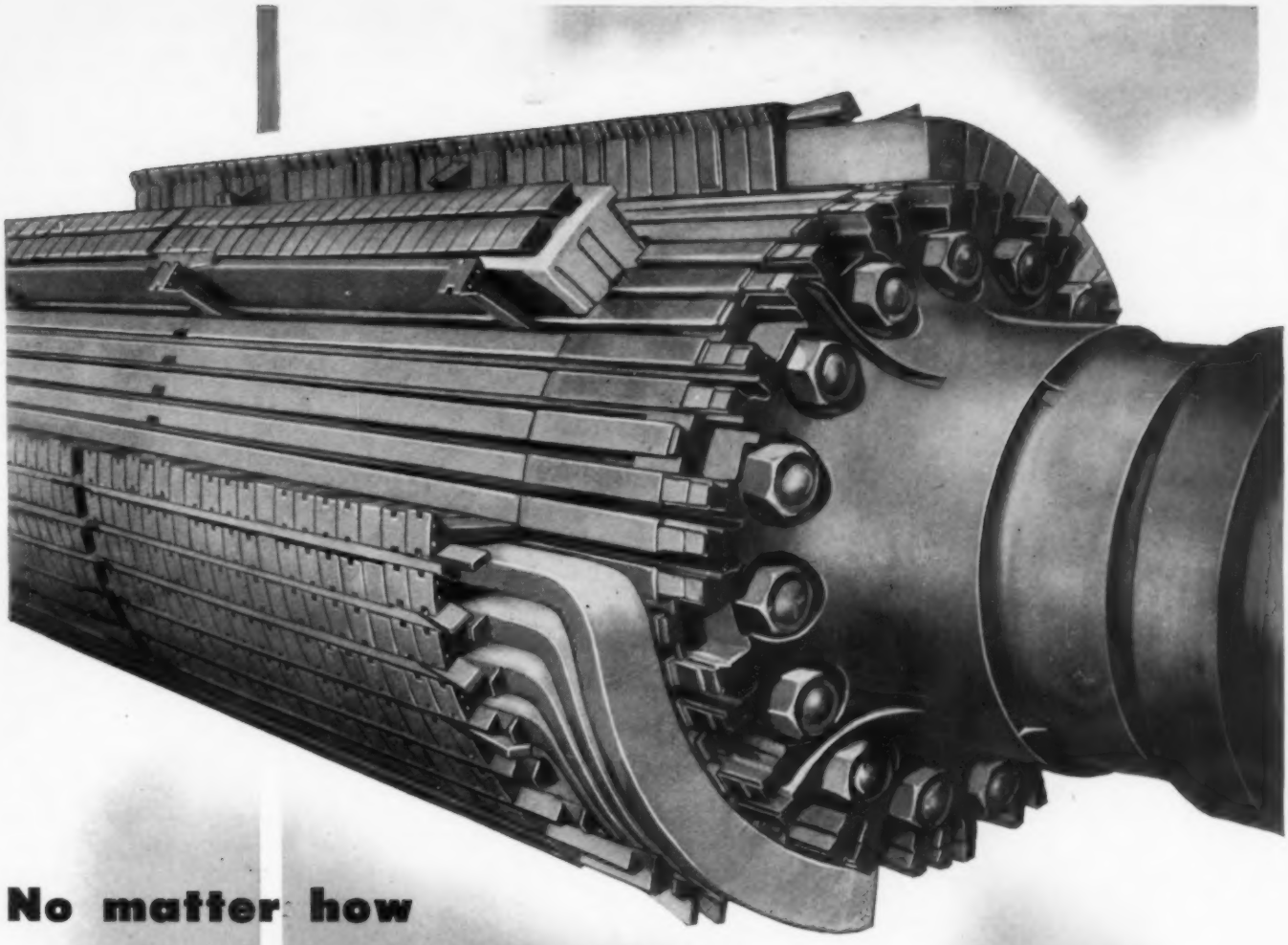


Figure 2 — All of the operations in the Inland Steel Co.'s new coal preparation plant at Price, Kentucky are controlled from this master pulpit, located in the center of the coal washery. Ash-forming refuse is automatically removed from the coal in two air-pulsated coal washers located to the left and right of the central walkway. As the coal passes through the washers it is subjected to the alternating upward and downward action of water, which causes the clean coal to rise and be discharged over a weir at the top, while the heavier impurities — clay, rock, slate, etc. — are automatically removed from the bottom as fast as they accumulate.

Mine rock can be handled at a normal uniform rate of 125 tons-per-hour, or up to 250 tons-per-hour for short periods when an abnormal amount of mine rock is encountered in a single trip of cars from the mine.

The run-of-mine coal, after being rotary-dumped into the coal hopper, passes by reciprocating feeder to a belt conveyor, which carries it to a combination screen and picking table and belt conveyor. Large rock is here handpicked from the coal while it is being carried down the mountainside to the run-of-mine shaker screens in the coal preparation building. Here all of the run-of-mine coal is separated into plus 5 in. (lump) and minus 5 in. sizes.

Coal received from other mines by rail or truck, so-called "foreign" coal, is discharged into a dump hopper equipped with a reciprocating feeder which delivers to a belt conveyor for discharge to the run-of-mine shaker screens. A link-belt car shaker facilitates the unloading of rail cars.



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ELECTRICAL ENGINEERS: MAKERS OF ELECTRICAL COILS AND INSULATION—

REDESIGNING AND REPAIRING OF ROTATING ELECTRICAL MACHINES

The lump coal (plus 5 in.) next passes from the sizing screens over a lump picking table where final picking removes objectionable material containing reclaimable coal, together with small rock that was not removed with the large rock. Rock hand-picked from the coal is delivered by chute to the rock crusher. The pickings removed for reclamation are crushed and feed back into the minus 5 in. coal coming from the run-of-mine shaker screen. The run-of-mine minus 5 in. coal belt is equipped with a magnetic head pulley for automatic removal of tramp iron. The picked lump coal may be delivered directly to rail cars by a car loading boom equipped with a hinged end to permit laying the coal gently in the car. An automatic car changing chute permits cars to be changed without interrupting the flow of coal.

The minus 5 in. coal is carried from the run-of-mine shaker screen to a 5-compartment blending bin. The coal is evenly distributed over the entire length of the bin by means of a motor propelled automatic-reversing steel tank-type tripper equipped with a two-way discharge chute. Automatic controls signal the operator when the bin is filled to capacity, or when the coal has reached its lowest operating level. The arrangement is such that a uniform layer loading of the blending bin is maintained at all times.

Raw minus 5 in. coal is fed uniformly from the five compartments of the blending bin by means of five belt feeders to five vibrating screens. P.I.V. variable speed drives on the belt feeders permit regulation of the rate of feed from the blending bins.

Figure 3 — Individual cars entering Inland's new coal preparation plant are weighed as they are being fed into the car dumper, where they are dumped two at a time without being uncoupled. The control panel for the trip feeder and car dumper can be seen between the scale room on the left and the dumper operator on the right.

On the vibrating screens the coal is separated into 5 × ⅜ in. and ⅜ × 0 in. fractions.

The 5 × ⅜ in. coal is delivered by belt conveyor to a shaking chute which delivers equal portions to each of two link-belt air-pulsated wash boxes. In the wash boxes the stream of raw coal passes over a perforated plate and is subjected to the action of periodic upward and downward currents of water. This action causes stratification of the coal and of the impurities according to their respective specific gravities. The low specific gravity (lighter) clean coal concentrates in the upper strata of the bed, while the heavier impurities — clay, rock, slate, etc., with their higher specific gravity and faster settling rate — accumulate in the lower strata. The upward current of the water raises the coal over the weir while the impurities are trapped.

Primary refuse from the two wash boxes is carried by the refuse conveyor system or to the refuse bins. Secondary refuse is rescreened at about 2 in. The undersize is carried away for disposal, while the oversize is crushed and delivered to the blending bin with the 5 × 0 in. coal. Fines are washed through the screen to the bottom where an endless screw carries them off.

The washed and cleaned coal from the wash boxes is sluiced with the wash water to the washed coal screens, on which the coal is separated into four sizes: 5 × 2 in., 2 × 1¼ in., 1¼ × ⅜ in., and minus ⅜ in.

The 5 × 2 in. coal may be delivered directly from the washed coal screens to the adjustable-end hinged loading boom to be laid gently into railroad cars for shipment. A portion or all of it, however, may be diverted by apron conveyor to a crusher, from where it is delivered to a paddle mixer in which it joins the natural 2 in. slack for loading into cars. It is possible, also, to by-pass the crusher and deliver the 5 × 2 in. egg to a domestic bin.

The 2 × 1¼ in. washed coal is delivered to the slack belt for transfer to the paddle mixer and thence to cars.

The 1¼ × ⅜ in. stoker coal may be delivered from the washed coal screens to a secondary dewatering screen for additional dewatering and discharge to a reversible belt conveyor for delivery to the car loading boom. However, it may be diverted to the slack belt for delivery to the paddle mixer and thence into cars.

The minus ⅜ in. coal which passes through the washed coal screens is pumped in its wash water to a settling cone. Settled solids are pumped from the settling cone to join the effluent from the concentrating tables before delivery to the centrifugal filters.

Cleaning coarse coal is not a particular problem, and is effectively handled as above. Present mining methods produce such a large percentage of minus ⅜ in. coal, however, that its treatment presents a major problem. The installation at Price represents an outstanding and thorough engineering solution.

The minus ⅜ in. coal which is received from the five vibrating screens at the blending bins is collected by belt conveyor and delivered into a surge bin. From the bin the coal feeds into a Sidekar-Karrier which distributes the coal to 18 hoppers at a constant rate to 18 Deister diagonal deck washing tables for cleaning.

Clean coal from the washing, or concentrating tables is then collected in sluices and delivered to five Bird centrifugal filters for dewatering. These dryers are built around a horizontal shaft and consist of two rotating elements. The outer is a solid bowl shaped like a truncated cone. This rotates at 650 rpm. Inside this bowl, and turning at a slightly different speed, is a helical conveyor. The solids settle, and are picked up by the conveyor and discharged through the small end of the bowl. The water discharges through the large end of the bowl head.

The water system provides maximum washing capacity with a minimum of water clarifying equipment. The major portion of the water used in the air pulsated washers is clarified in the 50 ft diameter settling cone and the Bird centrifugal filters are utilized for clarifying the water used on the concentrating tables. The clarified water from these filters is first pumped directly to the air pulsated washers where it joins a portion of the cone overflow and is used to wash the coarse coal, after which, it is pumped to the settling cone. The water required for the concentrating tables, is taken from the cone overflow and after clarification in the centrifugal filters, it is again returned to the air pulsated washers and is in effect used in both the coarse coal and fine coal washing processes.

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keeps automatics active and well fed

You'll find the familiar Mack-Hemp yellow-striped red wabbler rolls hard at work on the toughest jobs in efficient modern cold-rolled strip mills. In fact, Mack-Hemp strip mill rolls have been constantly improved to provide the productioneering tools required during the two decades when the demand for cold-rolled strip pyramided from 347,458 tons in 1931 to 1,591,038 tons in 1949.

From start to finish in rolling of strip, Mack-Hemp rolls are dependable producers in every operation. And, M-H engineers and metallurgists are engaged in continuous research and testing programs to provide striped red wabbler rolls which will stand up under ever-changing rolling conditions. That's why it's always important to keep an eye on what's new at Mack-Hemp.

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Makers of the Rolls with the Striped Red Wabblers

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MACKINTOSH-HEMPHILL PRODUCTS INCLUDE: rolls . . . steel and special alloy castings . . . completely integrated strip mills . . . heavy duty engine lathes . . . the new Mackintosh-Abramsen straighteners . . . improved Johnston patented corrugated cinder pots and slag-handling equipment . . . shape straighteners . . . end-thrust bearings . . . shears . . . levellers

F&Ym EQUIPS THE NATION'S STEEL MILLS to Speed Production

MACHINES, EQUIPMENT, ROLLS AND CASTINGS

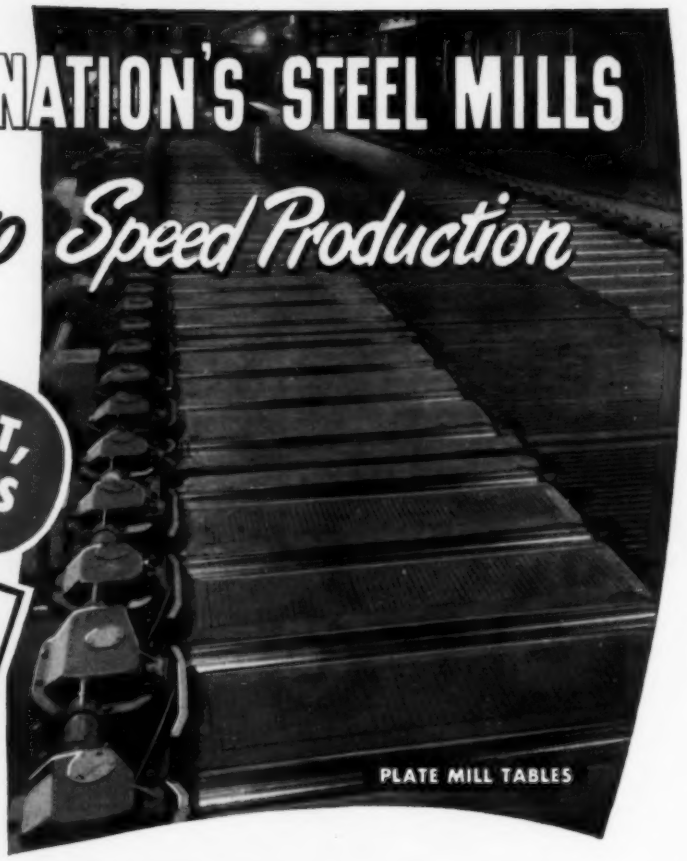
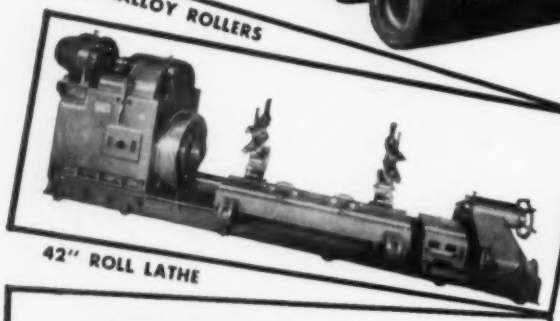
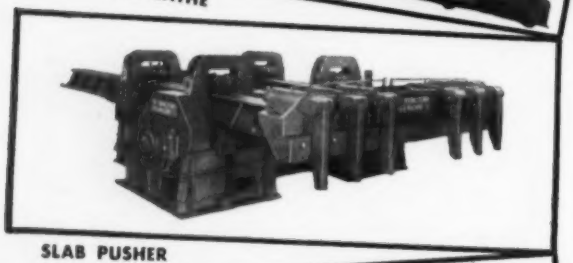
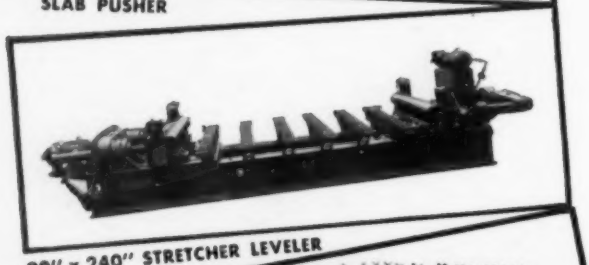


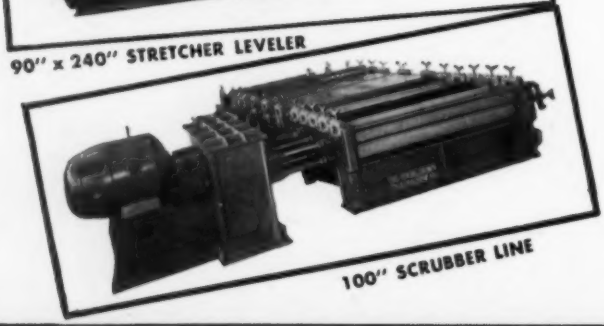
PLATE MILL TABLES

PARALLOY ROLLERS


42" ROLL LATHE


SLAB PUSHER


90" x 240" STRETCHER LEVELER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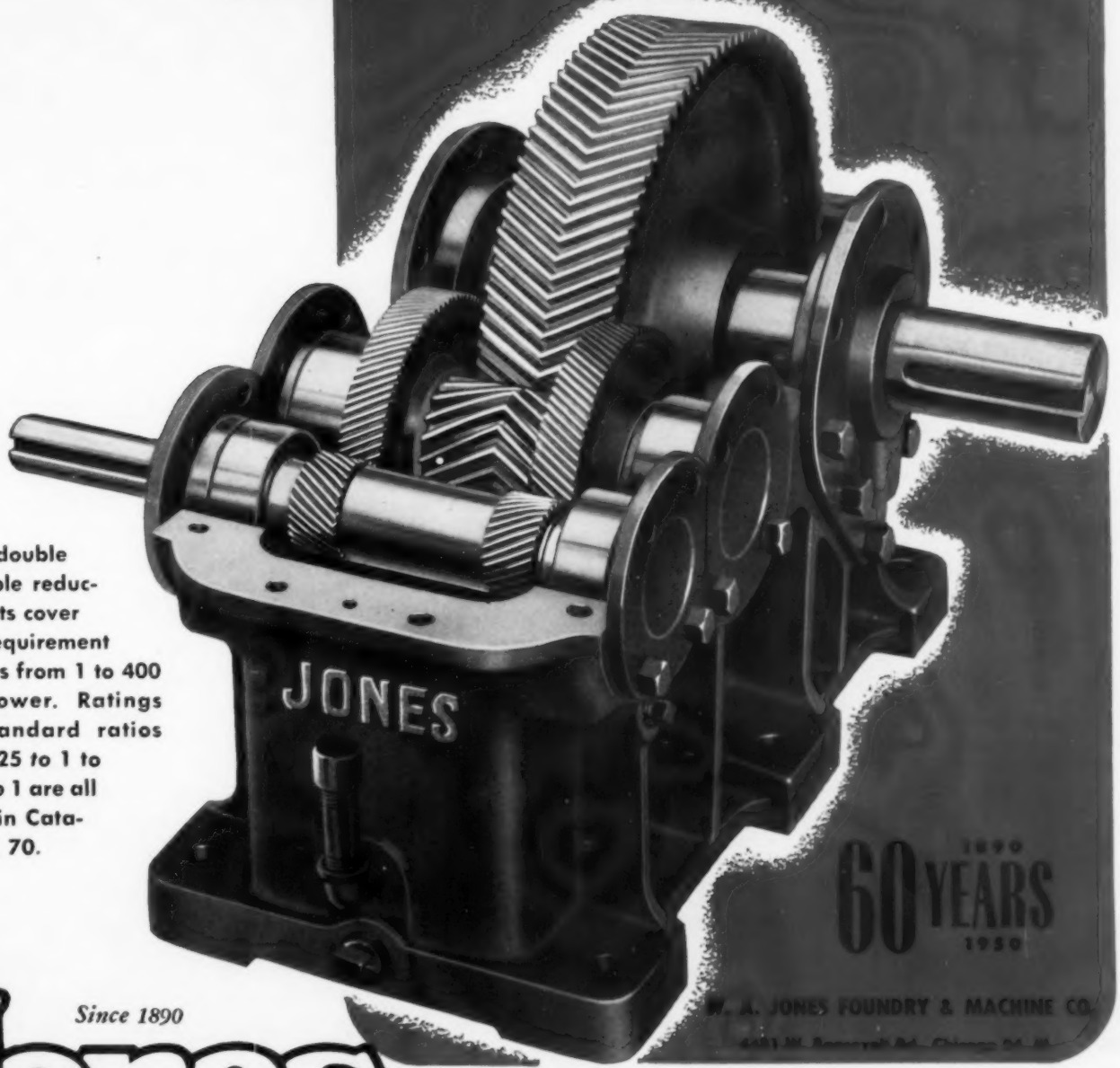

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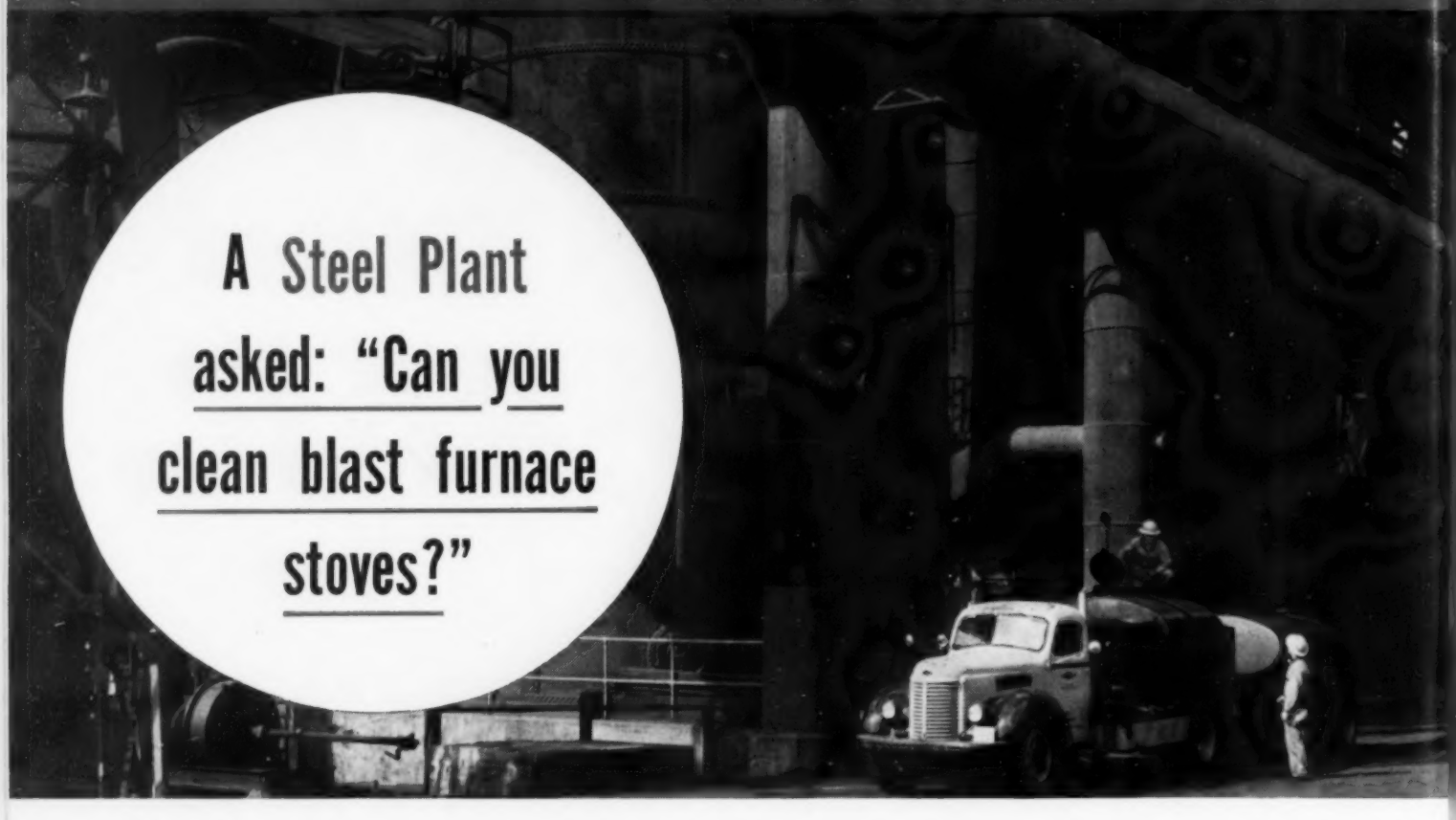

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The gas heating efficiency of two blast furnace stoves had fallen to 63.6% and 64.6%. In four working days, *without dismantling*, Dowell Service raised the efficiency of these stoves to 82.7% and 79.0%.

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Date-line Diary...

January 1

▲ It was reported that freight carload estimates for the first quarter of 1951 will be 16.5 per cent above the same period in 1950.

▲ The special House sub-committee which investigated monopolistic practices in the steel industry filed a report on their investigation. The report contained no recommendations for legislation.

▲ Based on reports of companies having 94 per cent capacity of the steel industry, the operating rate is scheduled at 101.8 per cent of capacity for the week beginning January 1, 1951. This is equivalent to 1,963,400 tons of steel ingots and castings compared with 1,930,600 tons one week ago.

January 3

▲ The Gulf Oil Corp., Cities Service, Pure Oil, Sun Oil, and Standard of Ohio plan to build a pipe line from West Texas to Gulf Coast refineries having a capacity of 300,000 bbl a day.

January 4

▲ Texas Gas Transmission Corp. plans a $42,300,000 pipe line construction program. Natural gas delivery on the Texas-Ohio pipe line will be increased by over 200,000,000 cu ft to 900,000,000 cu ft daily.

▲ President Truman signed a new tax bill. Regular corporate tax rate is 47 per cent and excess profits rate is 77 per cent.

▲ It was announced that National Steel Corp. will erect a new steel plant ten miles south of Camden, N. J.

▲ Pittsburgh Steel Co. announced that it planned to increase capacity 50 per cent. It will build a hot and cold rolled sheet mill and is thus entering the flat rolled products field.

January 5

▲ Railroad Traffic Officers announced they plan to ask for freight increases averaging about 6 per cent.

January 6

▲ The AAR reported that freight loadings in 1950 totaled 38,899,523 cars, a gain of 8.3 per cent over 1949.

January 7

▲ United States Steel Co. announced that it is initiating all rail shipments from upper Lake Superior to its Pittsburgh, Youngstown and Chicago district plants.

▲ United States Steel Co. blew out No. 2 furnace at Clairton for repairs.

January 8

▲ Based on reports from companies having 94 per cent of the steel capacity, the operating rate is scheduled at 102.7 per cent of capacity for the week beginning January 8, 1951. This is equivalent to 1,980,800 tons compared with 1,963,400 tons one week ago.

▲ President Truman, in a State of the Union message, stated that further tax boosts should be arranged to raise $8,000,000,000 to $10,000,000,000 annually.

January 9

▲ Purchases of zinc for the federal stock pile were discontinued for balance of the fiscal year.

▲ The AAR reports that deliveries of freight cars in December totaled 5700. Orders during the month totaled 3326, leaving a backlog on January 1 of 124,489. Total cars ordered in 1950 were 156,481, and deliveries were 43,991.

January 10

▲ Steel production in Great Britain in 1950 hit a new high figure of 16,292,700 tons.

▲ Price of tin set a new record at $1.69 a lb in New York.

January 11

▲ Tennessee Steel Corp. was organized to build an electric furnace plant in Scott County, Tenn. Annual capacity will be about 136,000 tons, and plant is expected to cost about $10,000,000, according to application filed with Security Resources Board.

▲ The government approved construction of $250,000,000 steel plant in New London, Conn. area.

January 12

▲ Allegheny Ludlum increased cobalt-bearing high temperature and electrical alloys 7½ per cent. Tool steels containing tungsten were increased up to 13½¢ a lb.

▲ AISI reported that steel production in 1950 reached a new high of 96,713,276 tons. Average operating rate was 96.7 per cent.

January 15

▲ The AISI announced that annual steel capacity effective January 1, 1951 is 104,229,650 tons, an increase of over 4,800,000 tons during the year. Blast furnace capacity on January 1 is rated at 72,471,780 tons.

▲ Based on reports from companies having 93 per cent of the steel capacity of the industry, the operating rate for the week beginning January 15 is scheduled at 99.6 per cent of capacity. This is equivalent to 1,991,000 tons compared with 1,980,800 tons one week ago. Capacity rate is based on new rated capacity figures.

January 16

▲ The ICC dismissed the petition of the railroads for 4 per cent increase, which was filed on December 1, because of the new 6 per cent request filed by the railroads.

▲ Wheeling Steel Corp. will build a 63-oven coke battery at East Steubenville, W. Va. at a cost of $8,750,000.

January 17

▲ Stock margin requirements were raised from 50 to 75 per cent today by the Federal Reserve Board.

▲ General Motors received an additional $106,000,000 contract for tank production for its Cadillac Division. Total commitments are now $500,000,000.

▲ E. B. Germany, president of Lone Star Steel Co., will raise $5,000,000 through a common stock offering, to help finance the company's expansion program.

▲ The RFC and DPA are approving a $73,425,201 loan for the construction of a steel plant.

▲ No. 1 blast furnace at the Ohio Works of United States Steel Co. went back into production.

▲ The AISI reports that average hourly wages in November were $1.763. Total employment was 653,200 and the average work week was 39.8 hrs.

January 18

▲ The F. W. Dodge Corp. announced that construction awards in 1950 in the 37 states east of the Rockies totaled $14,501,055,000 or 40 per cent above 1949. Construction awards in December totaled $1,168,432,000 or 7 per cent higher than November.

▲ United States Steel Co. will rebuild No. 5 blast furnace at its Ohio Works which will increase annual capacity 112,000 tons a year.

▲ It was rumored the Pittsburgh Steel Co. and Allegheny Ludlum were considering a possible merger.

▲ Carpenter Steel Co. will build a new $3,000,000 mill at Reading, Pa. Mill will be a unique combination for producing hot rolled strip, bar and rod.

▲ Jones & Laughlin Steel Corp. stockholders approved a 2 for 1 split in the company's common stock and a $30,000,000 increase in authorized indebtedness.

▲ John L. Lewis and a number of coal producers signed an agreement which provided for a 20¢ hourly wage increase. Operators estimated soft coal price would be increased about 6 per cent.

▲ Government awarded Chrysler Corp. a $99,000,000 contract to build tanks, and the Continental Motor Corp. a $100,000,000 contract to build tank engines.

▲ The government is putting two more magnesium plants into operation which will produce 220,000,000 lb in the next two years. One unit will be run by Dow Chemical Co. at Velasco, Tex. The other will be run by Kaiser Aluminum Co. at Manteca, Calif.

▲ Shareholders of the Reliance Electric and Engineering Co. approved a 2 for 1 split of the company's common stock, as well as an increase from the present 350,000 to 1,000,000 shares authorized.

January 19

▲ J. L. Collyer, president B. F. Goodrich Co., stated that production of rubber in 1951 should be about 2,800,000 long tons, of which 940,000 tons would be man made. World consumption in 1950 totaled 2,240,000 tons. Adequate supplies should be available to meet all essential needs.

January 20

▲ As part of its recently announced $50,000,000 expansion program, the Granite City Steel Co. is attempting to purchase the coke plant and blast furnaces operated by Koppers at Granite City, Ill. Koppers' plant consists of two blast furnaces with a combined capacity of 11,000 tons of pig iron a day, and 49 coke ovens producing 25,000 tons of coke a month.

▲ Truman dismissed Alan Valentine because Truman wished prices and wages frozen by February 1.

January 22

▲ Based on reports of companies having 93 per cent of the capacity of the industry, the operating rate for the week beginning January 22 is scheduled at 100.9 per cent. This is equivalent to 2,017,000 tons compared with 1,991,000 tons one week ago. This is the first time that over 2,000,000 tons of steel have been scheduled in any one week.

▲ H. G. Hilton, president Steel Co. of Canada, announced that they plan to boost capacity by 50 per cent at a cost of $40,000,000. Blast furnace capacity will be increased 450,000 tons to 1,270,000 tons, ingot capacity will be increased 650,000 tons to 1,900,000 tons.

▲ Tokyo Kohan Co., Ltd. of Tokyo ordered a cold rolling mill from United Engineering and Foundry Co., and an electrolytic pickling unit from Aetna Standard Engineering Co.

January 23

▲ The NPA ordered increases in the amount of steel which the producers must set aside for the defense program.

▲ Non-farm employment hit a record high of 46,400,000 in mid-December.

▲ E. R. Grace, chairman Bethlehem Steel Co., announced that his company is starting a $300,000,000 expansion program, which will increase ingot capacity 1,600,000 tons giving capacity at the end of 1951 of 17,600,000 tons. Of this, 1,080,000 tons will be added at Lackawanna, 740,000 tons at Sparrows Point, 352,000 tons at Steelton, 188,000 tons at Bethlehem, 180,000 tons at Johnstown, and 60,000 tons at Los Angeles. A new blast furnace will be built at Lackawanna.

▲ Cold wave cut use of gas by industry in the Cleveland area about 20 per cent, and in Pittsburgh, gas was curtailed from 50 to almost 100 per cent.

▲ Price of tin hit a new high of $1.79 a lb.

January 24

▲ President's Council of Economic Advisers announced that total production of goods and services in the United States in the fourth quarter of 1950 increased to an annual rate of $297,000,000,000.

▲ United States moved from seventh to third place in the world construction of merchant vessels during the fourth quarter of 1950.

▲ Great Lakes Steel Corp. will build a fourth blast furnace on Zug Island.

▲ Ford Motor Co. is planning thirty-seven additional coke ovens at its Rouge plant.

▲ The NPA banned the use of nickel in a long list of non-essential items.

▲ Bethlehem Steel Co. is buying top grade steel scrap in the Buffalo District for $52.00 a ton.

January 25

▲ Armco Steel Corp. awarded the Arthur G. McKee & Co. the contract for construction of its new blast furnace, the 76-oven coke plant went to Wilputte, and the F. H. McGraw Construction Co. received the railroad construction contract.

▲ Ford Motor Co. awarded Great Lakes Engineering Works a contract to build a new 647 ft ore ship which will have a capacity of 19,000 gross tons.

▲ The AISI announced that steel expansion plans will raise ingot capacity to 117,500,000 tons by the end of 1952. Blast furnace capacity will be increased to 79,300,000 tons by this date also.

January 26

▲ The Bethlehem Steel Corp. set a new record for earnings in 1950 of $122,976,071 or $12.15 a share compared with $9.68 in 1949. Total billings for 1950 were $1,439,821,948.

▲ The Board of Directors of Granite City Steel Co. recommended that the stock be split 2 for 1 and given a par value of $12.50 a share.

January 27

▲ The hard coal operators gave the United Mine Workers the same $1.60 daily wage increase which they received from the soft coal industry.

▲ Scrap prices advanced $5.00 to $51.50 a ton in Pittsburgh for a new record.

January 28

▲ The Northwest will get a 12-in. strip mill as a result of the organization in Seattle, Wash. of the Seidelhuber Steel Rolling Mill Corp. Mill will be of the steckel type.

▲ The AISC reports that February steel bookings for 1950 were 2,529,832 tons, the highest since 1930. December bookings were 224,808 tons. In 1950, shipments were 1,931,527 tons and shipments for December were 175,575 tons. The backlog for the next four months is 736,340 tons, and total backlog is 1,914,035 tons.

January 29

▲ Based on reports from companies having 93 per cent capacity of the industry, the operating rate for the week beginning January 29 is scheduled at 101.3 per cent of capacity. This is equivalent to 2,025,000 tons compared with 2,017,000 tons one week ago.

▲ Lukens Steel Co. will cut away a hill at the plant known as Union Hill to provide additional area for a contemplated $3,000,000 expansion.

▲ Cyrus S. Eaton announced that he is forming a fully integrated steel company to be located on a thousand acre site at Trenton, Mich. Firm will be named the Gibraltar Steel Corp. Initial plant capacity will be 700,000 tons of ingot steel annually, and estimated cost is $100,000,000. The president of the company will be Max J. Zivian, who is also president of Detroit Steel Corp. Further details are given in Industry News.

▲ The NPA issued five limitation orders on tin usage which call for thinner coatings and a ban on some items.

January 30

▲ National Steel Corp. acquired a 15 per cent interest in Reserve Mining Co. Remaining interest is owned by Armco Steel Corp. and Republic Steel Corp.

▲ Two finishing mills at Clairton and one at Homestead were shut down because of industrial gas curtailment in the Pittsburgh area.

▲ The Bureau of Mines reports that shipment of ore for 1950 reached an estimated total of 97,580,000 gross tons, and production reached 98,160,000 gross tons. Shipments were up 15 per cent and production was up 16 per cent above 1949. The Lake Superior district produced 81 per cent, and Minnesota alone produced 67 per cent of total U. S. production. Value of 1950 shipments were estimated at $488,000,000 or $5.00 a ton, compared with $4.50 in 1949. Shipments in 1951 will be up 60¢ more a ton.

January 31

▲ United States Steel Corp. reported sales for 1950 at a new high record of $2,955,000,000. Net income was $215,000,000 and profits average $7.28 a share compared with $5.39 in 1949. Earnings are the best since 1917 when gross sales were less than one-half that in 1950.

▲ Inland Steel Co. reported record sales in 1950 of $459,253,586 up 32.8 per cent from 1949. Net income was $38,015,676 or $7.76 a share compared with $5.11 in 1949.

▲ Armco Steel Corp. filed a registration statement which will offer about 884,000 shares of common stock to present shareholders on the basis of one share for each five shares held. Preliminary estimates of 1950 earnings are $46,000,000 or $11.50 a share compared with $7.68 a share in 1949.

▲ Truman proposed a tax program which would add a 4 point boost to the individual income tax rate, and raise corporate tax rates to 55 per cent.

▲ The rail switchmen strike started to affect freight shipments and spread from Chicago to St. Louis.

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CASE "A" — SLAB HEATING FURNACE
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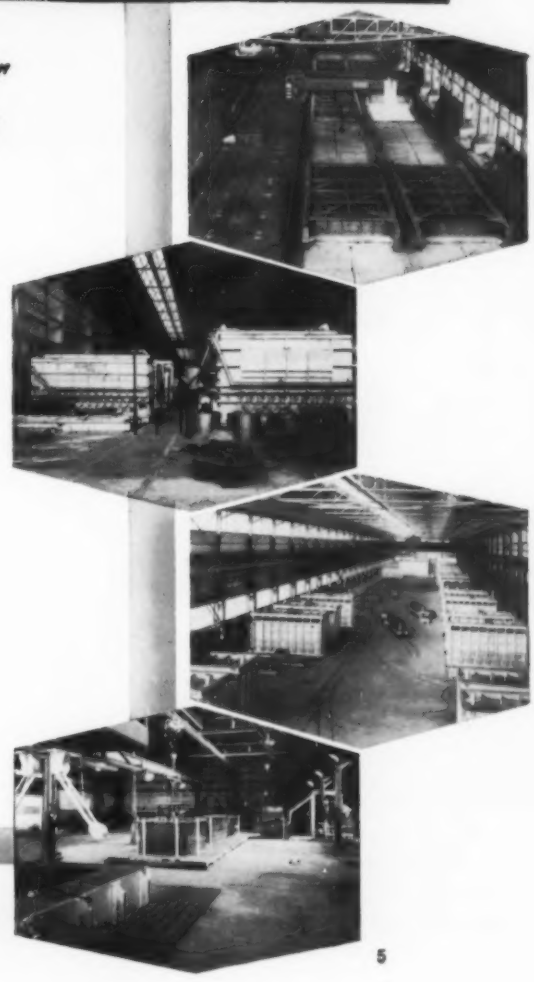
Write for Bulletin ... It tells about F. E. I. service ... complete from plan to production.



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SELECT YOUR MAGNET from two Ohio types. The PROTECTO-WELD magnet, shown here, is made in 39, 46, 55 and 65-inch diameters. Bolted construction types include these and other smaller sizes.

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Industry News...

BETHLEHEM ANNOUNCES $300,000,000 EXPANSION PROGRAM AT SIX PLANTS

▲ A $300,000,000 program of enlarged steel capacity by Bethlehem Steel Co. has been announced. Upon completion of the program, scheduled for the end of 1952, Bethlehem Steel will have an annual rated capacity of 17,600,000 tons. Over-all expansion by the company includes additional ore, coke oven, blast furnace, rolling mill, transportation, electric power and other facilities. The program will add 2,600,000 net tons of steel ingots to Bethlehem's capacity as it was on January 1, 1950. This includes 1,000,000 net tons that became effective during the last year.

The 2,600,000 additional tons are distributed at Bethlehem's major steel plants in the following amounts: Lackawanna, N. Y., 1,080,000; Sparrows Point, Md., 740,000; Steelton, Pa., 352,000; Bethlehem, Pa., 188,000; Johnstown, Pa., 180,000, and Los Angeles, Calif., 60,000.

A battery of seventy-six new coke ovens has been approved for the Lackawanna plant and sixty-five for Sparrows Point. Two seventy-seven oven batteries were authorized during the past year for the plant at Johnstown.

Bethlehem Steel obtains much of its iron ore from its own mines and also purchases substantial tonnages from both foreign and domestic sources. The Venezuelan mine is in operation and it is expected that the first shipment to the United States will arrive this month. Shipments will increase steadily throughout the year, and it is hoped that a million tons will be received from this source during the year, increasing annually thereafter.

ARMCO'S HOT STRIP MILL IS MODERNIZED

The hot strip mill modernization program at Armco Steel Corp.'s East works, Middletown, Ohio, has been completed in record time. The three million dollar construction program required eight months of planning and was expected to require 15 days of work, but actually was back in operation in only 12 days. The project included installation of six heavy stands of mills at the finishing end of the hot strip mill, rebuilding of cranes, runways, soaking pits, tracks, tables, shears, slab furnaces, main drive motors and generators, and coilers. During the 12-day period the hot strip mill was down, the furnaces at the plant continued to produce ingots and bank them. Because Armco had built up an inventory of hot rolled sheet coils, all departments of the mill were able to continue production at practically full operating rates.

PORTSMOUTH FACILITIES TO BE EXPANDED

▲ A $50,000,000 expansion program at Portsmouth, Ohio has been announced by Detroit Steel Corp. The new facilities will include a second blast furnace, rated at 1,400 tons. Annual ingot capacity will be boosted to 1,290,000 tons a year and finishing capacity from 180,000 to more than 1,000,000 tons a year. There will be four additional open hearth furnaces of 250-ton capacity each, a new blooming mill, a new 54-in. hot strip mill, and a new 54-in. cold rolled sheet mill.

INTEGRATED PLANT TO BE BUILT IN TEXAS

▲ With a government loan of $73,425,201 in hand, Lone Star Steel Co. officials plan to break ground at once in starting construction of a completely integrated steel mill to be located adjacent to the firm's present blast furnace, coke ovens and related facilities in East Texas. Iron ore is mined within sight of the blast furnace. Coal is produced in company mines only 200 miles from the plant site. Consumption of a major portion of the company's production is expected to occur within a radius of 300 miles of the plant.

The steel and pipe finishing plant will supplement the existing Lone Star plants. The present plants include a blast furnace with a capacity of about 400,000 tons of pig iron per year, a battery of coke ovens with a capacity of 375,000 tons of coke per year, a by-products plant which produces coal tar, ammonium sulphate and several light oils, a cast iron pressure pipe foundry with a capacity of

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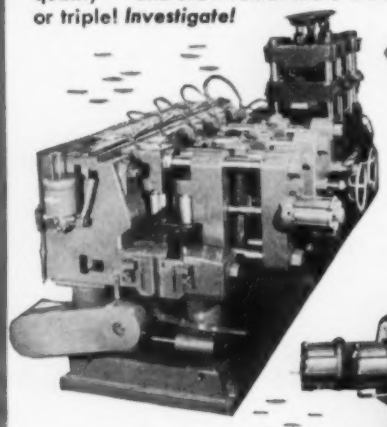
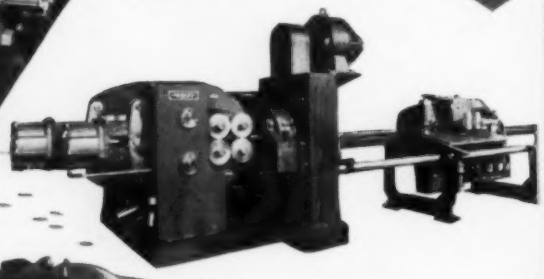
COLD FINISHING MACHINES

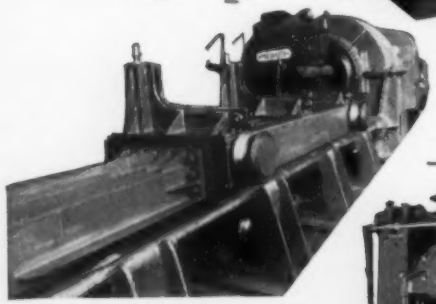
Medart Equipment can fulfill today's urgent demand for ***more and faster production!*** Used in virtually every steel and non-ferrous mill in the country, Medart Machines have ***proved*** they can keep costs down — give closer control over quality — and show remarkable increases in output, in some cases almost double or triple! ***Investigate!***



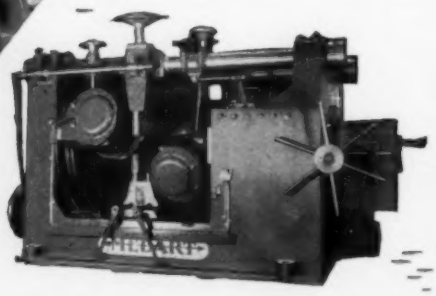
SHAPE STRAIGHTENER — Model TPVC
For large production at extremely high speeds. Handles squares, flats, octagons, hexagons in 2 planes without roll changes.

CENTERLESS BAR TURNER
Doubles grinding department production. Patented "torque-chipping" feature and push-draw feed turns bars small as ¼" at very high speeds.





BILLET PEELERS
A complete line handles ferrous or non-ferrous billets 1" to 14" in diameter at up to 40 ft. per minute.



STRAIGHTENING, SIZING, POLISHING MACHINES
Equipment to meet every need for precision top-speed production on round bars, tubing and pipe. "Medart Finish" has become the standard of the industry.

Write FOR CATALOGS
Straightening, Turning, Polishing, Sizing Machines—Bar And Billet Peelers—Centering Machines—Tube Derodders—Bar Pointing Machines, etc.

THE MEDART COMPANY

80,000 tons annually, and various minor facilities for the production of light concrete aggregate from slag.

Raw materials for the pig iron and coke operation include the major holdings of East Texas iron ore, and extensive deposits of coal in Oklahoma mines owned and operated by Lone Star.

The proven ore supplies of the company are known to be sufficient for a minimum of 42 years of operation of the present blast furnace; coal owned by Lone Star constitutes a 32-year supply. The coke plant has a capacity in excess of blast furnace requirements, can supply 8,500 tons per year to foundries and other industries of Texas.

The purpose of the steel plant construction is to supply the present day unfulfilled demand within Texas and adjoining states for tubular products, chiefly for oil country use and related requirements. Within this territory about 75 per cent of the domestic petroleum is produced with a corresponding degree of activity in the search for new fields.

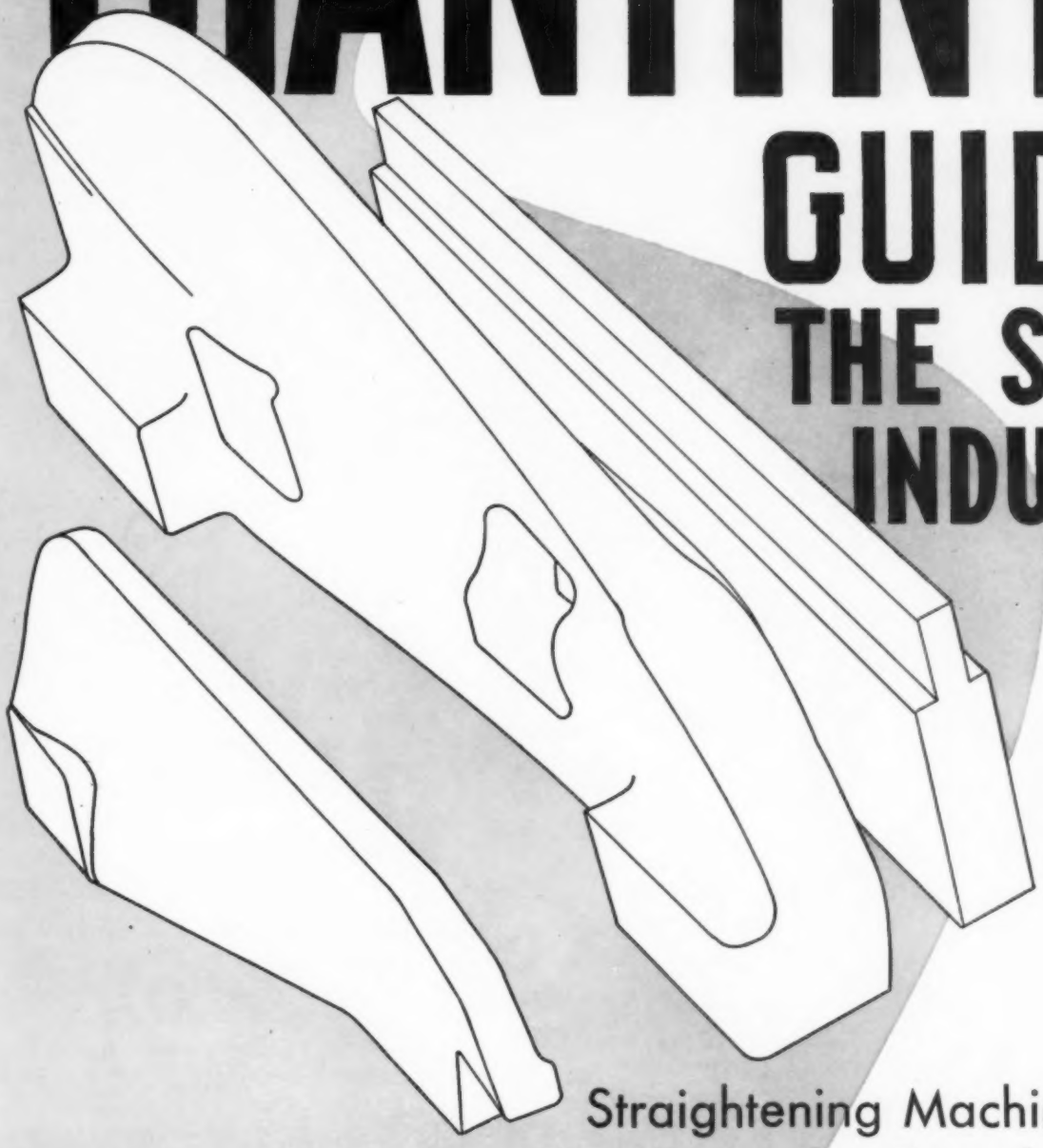
The Lone Star project will use the basic open hearth process to make steel. The open hearth plant will have four furnaces. These are to be built on 100 ft centers with a hearth length of 50 ft, a width of 16 ft and a nominal bath depth of 28 in.

The rolling mills to be installed

FUEL OIL RESERVE

This 4,000,000 gallon storage tank nearing completion at Duquesne, Pa., works of United States Steel Co. will hold a reserve of fuel oil for operation of U. S. Steel's open hearth furnaces in the Pittsburgh district when the supply of natural gas is low. The furnaces are being equipped for emergency conversion to fuel oil. Railroad and barge docking facilities, pumps, piping overhead pipelines from the tank to the furnaces, and other auxiliary equipment are being installed. A safety wall will surround the 48-ft high, 120-ft diameter tank.

TRANTINYL GUIDES THE STEEL INDUSTRY



Straightening Machine Guides
for Rounds and Pipe

YOUNGSTOWN ALLOY CASTING CORP., YOUNGSTOWN, OHIO

Production · Quality · Yield

"MULTICUT" "TUFCUT" "HOT WORK"
Wapakoneta
SHEAR BLADES
and ROTARY KNIVES
Any type or size blade of proper Alloy with correct hardness and temper for every type shearing machine and every kind of job.
TOOL
Rx ENGINEERED TO THE JOB
Every Wapakoneta blade is made to exact specifications, designed for the particular job. Complete records with order number of each blade makes possible duplication of exact size and temper at any time.
The WAPAKONETA MACHINE CO.
Shear Blade Specialists Since 1891
Wapakoneta, Ohio

were planned so that the plant might be expanded at a later date. Initial construction calls for a 2-high mill. It will produce plates measuring 44 in. by 110 in., and will be followed by a Steckel mill.

The plant will utilize the electric weld method for making pipe from the coiled strips of steel.

The upset department will make those grades of pipe where strengthened ends are required.

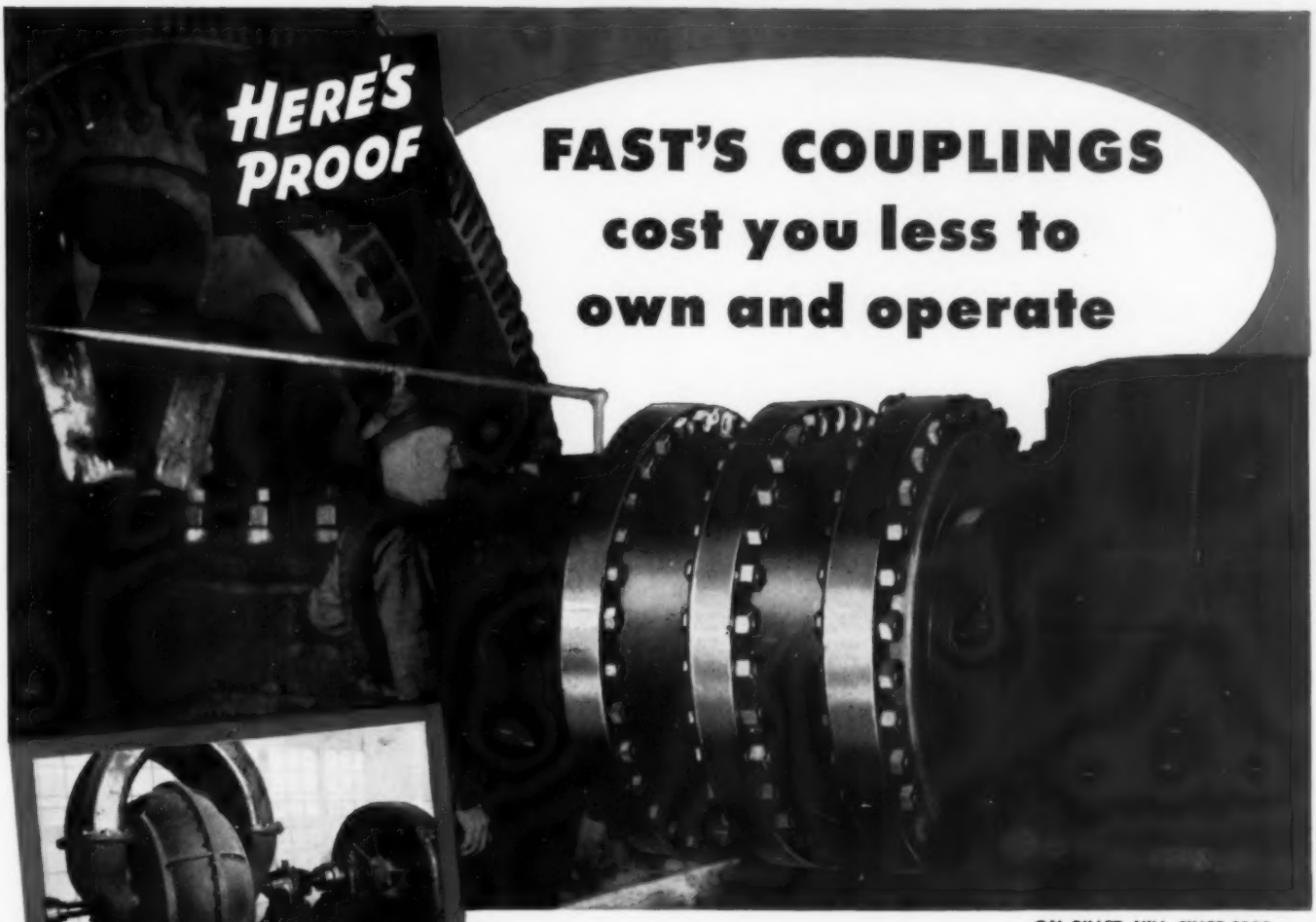
Officials pointed out that the construction of the new plant would place heavy demands on the company's power plant and would necessitate considerable expansion of present facilities. Additions to the power plant will enable Lone Star to generate a total of 25,000 kw against a peak demand of about 40,000 kw. This plant will supplement present facilities. Other requirements of the overall system will be furnished by present facilities.

As for production figures, officials estimated the steel plant would be able to turn out 500,000 tons of steel ingots from which 350,000 tons of welded steel pipe may be furnished. Pipe will be produced in diameters from 2 to 16 in. Use of pig iron in producing the steel pipe will not interfere with Lone Star's cast iron pressure pipe foundry operation which uses about 72,000 tons of iron a year.

NATIONAL REVISES CAPACITY FIGURES

▲Further developments in the expansion program of National Steel Corp. will revise upward the ingot capacity to be achieved during 1952 to a total of 6,000,000 tons. In previous announcements, it had been stated that National would increase ingot capacity from 4,500,000 tons to 5,500,000 tons by 1952. The new figure of 6,000,000 tons will be an increase of 1,500,000 tons, or 33⅓ per cent, over the 1950 ingot capacity of 4,500,000 tons. Part of the increase became effective as of January 1, 1951, when National's ingot capacity was established at 4,750,000 tons.

The 6,000,000-ton capacity figure does not include any tonnage for the new plant to be constructed by National Steel Corp. on the Delaware River, near Camden, N. J., but will result entirely from additions to and enlargement of blast furnace and open hearth furnace facilities at the



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Fast's Couplings cost you less per year because they normally outlast the equipment they connect. That means their reasonable cost can be spread out over 20 years or more . . . assuring low-cost service without excessive maintenance costs!

Fast's basic design is *foolproof!* Instead of a perishable oil seal, Fast's are the only couplings to use a *permanent* metal-to-metal closure. Oil is always maintained at a safe level . . . whether the coupling is running or standing still . . . and dirt cannot get in. Fast's Couplings are compact, yet large enough to stand up under punishing service for 20 years or more!

When you specify Fast's Couplings, you get Koppers' valuable engineering service. In many cases where a special coupling appears necessary, Koppers engineers can modify a standard Fast's and save you money! Get the facts on Fast's Couplings. Mail the coupon for your copy of Fast's *free* Catalog today!

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Gentlemen: Send me Fast's Catalog which gives detailed descriptions, engineering drawings, capacity tables and photographs.

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THE ORIGINAL GEAR-TYPE

Couplings

INDUSTRY'S STANDARD FOR 31 YEARS

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plants of Great Lakes Steel Corp., Detroit, Mich., and Weirton Steel Co., Weirton, W. Va.

When the program is completed, the annual ingot capacity of Great Lakes Steel Corp. will be 3,600,000 tons and that of Weirton Steel Co. will be 2,400,000 tons.

ALCOA BUILDS NEW ALUMINA PLANT

▲ Aluminum Co. of America will build a new alumina plant near Bauxite, Ark. Construction of the plant is to begin immediately. Designed to process low-grade bauxite ore, the new plant will increase by nearly 50 per cent the amount of alumina now being produced by the company. Alumina is the refined ore from which basic aluminum is obtained by the smelting process.

To be operated by Aluminum Ore Co., wholly-owned subsidiary of Aluminum Co. of America, the new plant will be situated on a 200-acre site adjoining the bauxite mining operations of Alcoa Mining Co., also a wholly-owned subsidiary of Alcoa. Long the largest domestic source of ore for the aluminum industry, the Arkansas area thus assumes added importance in this nation's aluminum producing industry.

Low-grade bauxite will constitute the raw material for this proposed plant, its use having been made possible through an Alcoa development achieved early in World War II. At that time, to provide for the greatly increased amounts of alumina required by the war-time aluminum producing plants, Alcoa developed a combination lime soda-Bayer process which for the first time permitted the economical use of low grade bauxite for aluminum production. Previously, only high grade bauxite had supplied the aluminum industry's alumina requirements. During the war the process was used at plants built and operated by Alcoa for the government. After World War II, with the disposal of these plants to other producers, Alcoa released to such operators, without any payment or royalty, its patents on the process. The new alumina plant will use this process in its operations.

The entire construction project will be carried out by Alcoa, serving as its own general contractor. At the

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TRADE-MARK

Biggest advance in 50 years of industrial brush selling

● Here is a tremendous advance in industrial brush selling. National Carbon has set up a list of steel-mill brushes — for mill-type motors, for sk. motors, cd. motors, and other widely used types — which effectively covers the field. These brushes are the best ever made for this equipment. They will give you top performance. And you can get them at a *low, flat price — regardless of quantity* — so long as you order at least one box of brushes. You get the brushes quickly. They are kept in stock. Finally, you get the brushes in a sturdy, durable box. You get *better brushes* . . . at a *better price* . . . in a *better package.*

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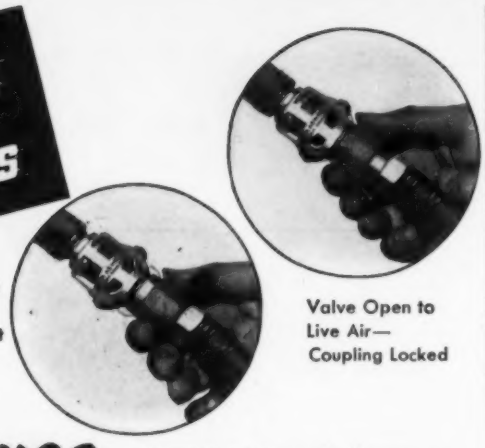
Quick-As-Wink
AIR AND HYDRAULIC
Control Valves



Valve Closed to Live Air— Open to Exhaust

Valve Open to Live Air— Coupling Locked

VALVE COUPLINGS ¼", ⅜", ½", & ¾" SIZES

For Economy and Safety

● These couplings permit air to be shut off and tools changed quickly without going to the main shut-off valve. Coupling jaws are automatically self-locking when valve is open to air supply. The coupling cannot be disconnected until the valve sleeve is moved to closed and exhaust position,— thus preventing accidents and injuries. Pressures to 250 p.s.i.—hose shank, male or female pipe connections. *Send for Bulletin No. 104-C. It gives full details and prices.*

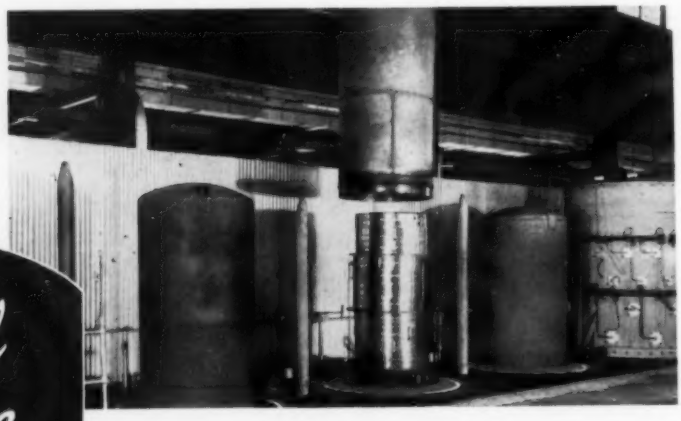
THE HIGHER THE PRESSURE THE TIGHTER THE SEAL

Quick-As-Wink
AIR AND HYDRAULIC
Control Valves

Hand, Foot, Cam, Pilot, Diaphragm and Solenoid Operated

Mfd. by C. B. HUNT & SON, INC., 1986 East Pershing St., Salem, Ohio

EF



Bell Type FURNACES

for annealing, carburizing, nitriding and other processes

EF Bell or Hood type furnaces may be used for a wide variety of products and processes—and the cycle readily changed to suit the process. The gas fired installation above bright anneals strip. Other fuel fired and electric units are available for normalizing rod, annealing wire, laminations and other products—for malleableizing, carburizing, nitriding and other processes. A single furnace serves several bases. Forced circulation assures rapid and uniform heating of the entire charge regardless of the weight, size, height or density of the load. We build batch or continuous furnaces for any heat treating requirement. We solicit *your* inquiries.

Gas-Fired, Oil-Fired EF *and Electric Furnaces*
for any Process, Product or Production
THE ELECTRIC FURNACE CO.
WILSON ST. at PENNA. R. R. *Salem - Ohio*

present time, designs for the new plant are practically completed and orders for necessary materials are being placed.

WOOD WORKS BECOMES PART OF IRVIN WORKS

▲ In a move to consolidate further the manufacture of sheet steel in the Pittsburgh district, Wood works, the stainless steel processing plant of United States Steel Co. in McKeesport, Pa., has become the Wood works plant of Irvin works, it was announced by S. M. Jenks, vice president-manufacturing.

Carl M. Nystrom will remain as superintendent of the Wood works plant and there are no changes contemplated in the management personnel of the plant.

This consolidation follows a similar one of several years ago when the Vandergrift plant of the company was made the Vandergrift plant of Irvin works.

Products produced at Wood works are principally hot and cold rolled stainless steel sheets. Vandergrift produces semi-finished steel and electrical sheets, and Irvin works hot and cold rolled sheets, tin plate, black plate and galvanized sheets.

CARPENTER TO ADD NEW HOT ROLLING MILL

▲ A new hot rolling mill will be built by Birdsboro Steel Foundry and Machine Co. for Carpenter Steel Co., Reading, Pa. Estimated cost of the mill machinery contract is in excess of $1,250,000.

The new mill will be a combination strip, bar, and rod mill and will be completely designed, engineered, and built by Birdsboro to special requirements of Carpenter. It will be unique in providing for substantial tonnages of these diverse products, while being arranged for maximum flexibility in changing to different orders, and the most modern practices for assuring quality control will be used throughout. The roughing unit will consist of one 2-high reversing and one 3-high mill. The strip mill will be of continuous 2-high construction. The bar mill will consist of 2-high mills served by mechanical transfers and manipulators. The rod mill will

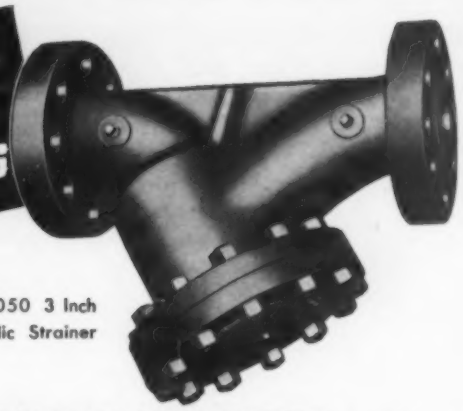
include several looping stands with repeaters and will also include a continuous 4-stand mill for finishing down to ¼ in. rounds and small flats. Mechanized handling equipment will be provided for all three classes of products.

The mill will produce material for Carpenter's own cold rolling and cold drawing departments as well as products for direct sale as hot-rolled products, and will enable the plant to substantially improve production for faster delivery to consumers.

CONTRACTS AWARDED BY ARMCO STEEL

▲Armco Steel Corp, announced that contracts have been negotiated for the $35,000,000 blast furnace and coke ovens soon to be built at Middletown, Ohio. This huge construction project was announced last fall when the company started operations of its new $12,000,000 open hearth department. Arthur G. McKee Co. has been awarded the contract to build the blast furnace. Wilputte Coke Oven Division of the Allied Chemical & Dye Corp. has been awarded the contract for building 76

Quick-As-Wink AIR AND HYDRAULIC Control Valves



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HIGH PRESSURE HYDRAULIC STRAINER to 1500 p.s.i.

protects valves, cylinders and spray nozzles

●Electric furnace cast steel housing. The strainer consists of machined and grooved bronze rings nested around a heavy slotted multi-ported bronze back-up cylinder. The rings can be loosened and cleaned easily with compressed air, or completely removed and cleaned in solvent. Repay their cost many times over. Widely used in steel mills and forging shops to prevent partial plugging of spray nozzles, resulting in rejects due to scale streaks. 1½" to 6" sizes. Send for Data Sheet No. 3402. It gives full details.

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Hand, Foot, Cam, Pilot, Diaphragm and Solenoid Operated

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OAKITE Compound No. 33 is a cleaning-phosphating material that simultaneously removes oil and rust and conditions the metal surface for painting.

It's a great soak cleaner for metal parts of moderate size; and great for hand-swabbing on large pieces like cabinets, desks, doors and truck cabs.

Oakite Compound No. 33 saves money, *frequently eliminates pickling operations on moderately rusty steel.*

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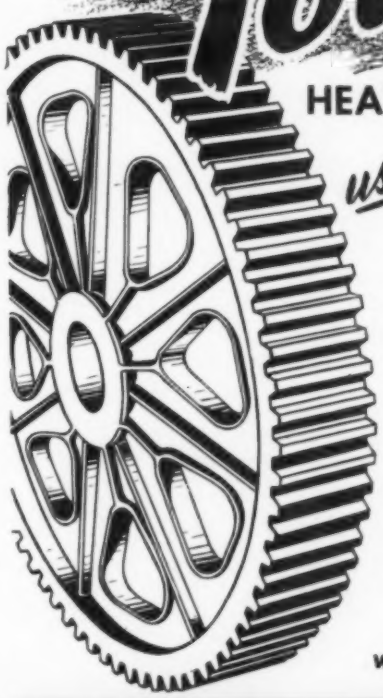
OAKITE SPECIALIZED INDUSTRIAL CLEANING MATERIALS • METHODS • SERVICE

FOR THE Tough HEAVY DUTY JOBS use



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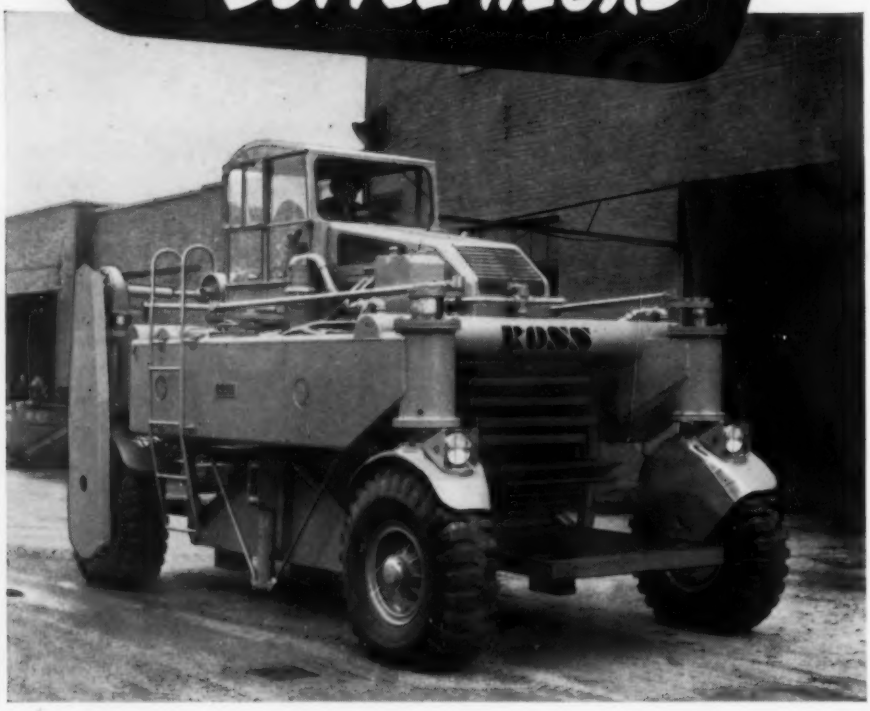
STEEL HANDLING
BOTTLE NECKS



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...simplest mass handling method known!

Now... you can move 45,000-pound payloads of billets, bars, plate, in-process and finished steel *where* you want them *when* you want them... at a moment's notice!

Now... you can be free of the restrictions of a plant railroad handling system... its expensive trackage, cars, locomotives... costly, time-consuming switching operations!

Now... you can prevent congestion in the mill... free more mill space for production operations... eliminate costly re-handling ... save time and money in getting out current orders!

How? With Ross Series 100... the *only* Carriers designed and built all the way through for rough, tough steel mill service... the *only* Carriers with that great reserve strength steel men demand. Self-loading and unloading, Ross Series 100 requires only a driver... and moves capacity loads at speeds up to 33 mph.

Don't overlook the outstanding advantages of the Ross Carrier Steel Handling Method... ASK STEEL MEN WHO *KNOW!* Get full details on Ross Series 100 Carrier... a 'phone call, wire or letter will do it.

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coke ovens and by products plant.

F. H. McGraw Construction Co. received contracts to construct railroad tracks, roads, sewers and other items. Construction will start as soon as deliveries of steelwork and equipment can be made.

SHIP WHITE-HOT INGOT 200 MILES BY RAIL

▲ A saving of nearly two months of processing time was achieved when a white-hot ingot was recently shipped by rail from Dominion Iron and Steel, Ltd., Sydney, Nova Scotia, to Trenton Steel Works, Ltd., 200 miles away in Trenton, Nova Scotia.

In what is believed to be the first such shipment anywhere, the 30,000-lb ingot left Sydney with a temperature of 1,770 F late in the afternoon. When the Trenton plant went to work on it the next morning, it still retained a temperature of 1,575 F.

This precedent-shattering trip was made possible because the ingot was insulated with vermiculite, a mineral of the mica family, mined by the Zonolite Co.

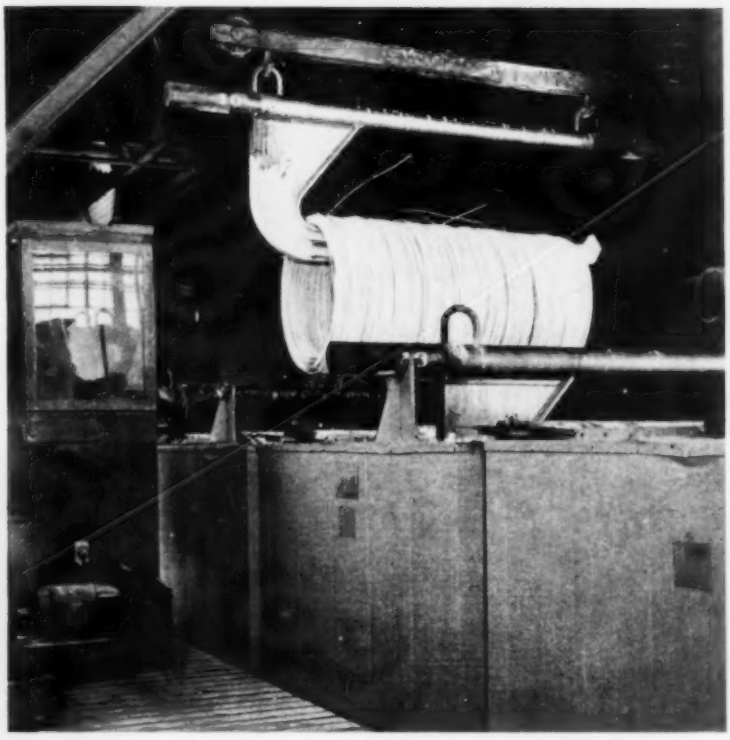
Traditionally, such a shipment has been a time-consuming operation. The ingot would have had to be cooled before being transported, a process requiring six long weeks. At its destination, it would have had to be reheated for 10 days before work could be continued.

At the Dominion plant the huge, hot ingot was allowed to solidify in a mold, was stripped and placed in a cast iron box insulated with premolded vermiculite. The remaining space was then filled with loose vermiculite, and a steel lid placed on the box. This was then securely fastened and braced to the railway car floor.

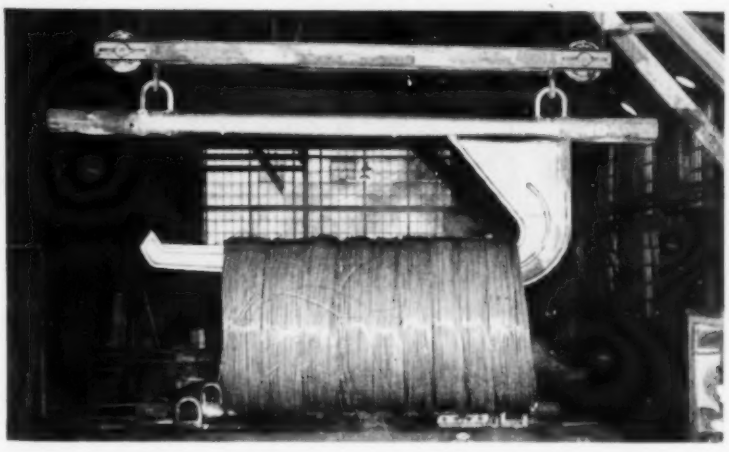
USE THE ENGINEERING MART

For Top-Most Value in Wire and Wire Rope Today it's *Roebling*..

And WELDCO Hairpin Pickling Hooks *Help Maintain this Roebling Quality Leadership*



Weldco hook and wire, coming from the lime tank, are about to enter the baker.



A Weldco hook, carrying coiled wire, is shown emerging from hot sulphuric acid.

The John A. Roebling's Sons Company has one of the largest specialty wire mills in America. From steel-making to finished wire—throughout every operation—quality is assured by Roebling techniques and modern manufacturing facilities. In the handling of coiled wire, for instance, Roebling uses 18 Weldco pickling hooks, and each one carries 60 tons of wire per day!

Weldco hairpin pickling hooks combine light weight, toughness and high strength. Made of long-lasting, corrosion-resistant Monel, they handle payloads up to 4200 pounds, withstand sulphuric acid solutions, and outlast bulky cast hooks 2 to 3 times. These easy-to-handle hooks have outstanding service records, and offer, also, many other cost-cutting, time-saving features:

SUPERIOR DESIGN

Readily adaptable to all types of handling equipment.

Fast, easy loading and unloading of coils.

"Single-point contact" between hook and coil, provides more thorough pickling and cleaning.

Jacketed Monel spreader keeps rusty moisture from falling onto the coil . . . reduces damage and rejects at the draw bench.

ECONOMICAL, EFFICIENT OPERATION

Big savings in the low, initial cost.

Long production life—years and years of heavy-duty service.

Bigger payloads—fewer "trips"—less cost per ton.

Less maintenance—fewer replacements because of the excellent resistance of rolled Monel to sulphuric acid and fumes.

No breakage, because of Weldco's unusual strength.

Leading wire mills throughout the country have discovered that Weldco lightweight hooks reduce pickling costs and improve production methods. Our Engineering Department will be glad to give you further information . . . and offers complete engineering service on your entire pickling line.

THE YOUNGSTOWN WELDING & ENGINEERING COMPANY

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UNION CARBIDE AND CARBON CORPORATION
30 East 42nd Street, New York 17, N. Y.
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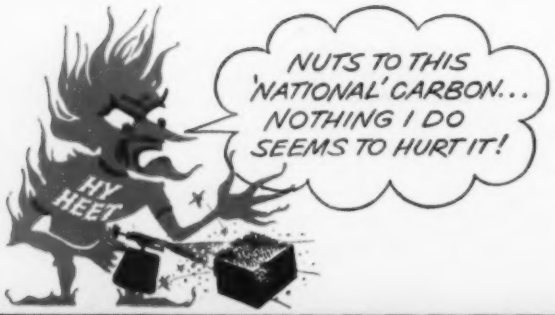
In Canada: National Carbon, Ltd., Toronto 4

15 blast furnaces in the U.S. have each produced over 1,000,000 tons of iron on a single "National" carbon lining . . . and are still going strong!



BLAST FURNACE LININGS • BRICK • CINDER NOTCH LINERS • CINDER NOTCH PLUGS • SKIMMER BLOCKS • SPLASH PLATES • RUNOUT TROUGH LINERS • MOLD PLUGS • TANK HEATERS

Personnel News...

Albert J. Berdis was appointed general superintendent of United States Steel Co.'s Fairless works. Mr. Berdis will manage operations of the new, wholly-integrated mill which U. S. Steel recently announced it would build near Morrisville, Pa. Construction of the mill will begin early in the spring. A native of Whiting, Ind., Mr. Berdis is a graduate of Purdue University, where he received a degree in electrical engineering. In 1929 he began with U. S. Steel in Gary, Ind., as a fuel engineer in the Gary sheet and tin mill. In 1935, when U. S. Steel was drawing up plans for the Irvin works, Mr. Berdis was transferred to Pittsburgh to become the chief design engineer for the plant which is among the most modern sheet and tin plate mills in the world. Later he became chief engineer of the Irvin works and in 1945 was appointed assistant to the general superintendent. In 1947, Mr. Berdis became superintendent of the U. S. Steel plant in Vandergrift, Pa., which specializes in the production of electrical sheets. Last year, in February, he returned to the Irvin works as assistant general superintendent. For the past several months he has been working on the layout and design of the Fairless works.

Henry E. Warren, Jr. was named assistant general superintendent, and **Forest J. Smith** was appointed assistant to general superintendent of the new Fairless works of United States Steel Corp. to be built at Morrisville, Pa. Mr. Warren has been division superintendent of open hearth furnaces at the company's Homestead district works and Mr. Smith has been supervisor of labor relations with headquarters in Pittsburgh.

John H. Elliott was named general manager, manufacturing, and **William C. Oberg** was appointed manufacturing consultant, for United States Steel Co., Pittsburgh, Pa. A native of Elwood, Ind., Mr. Elliott studied engineering at the University of Pittsburgh and started with U. S. Steel in 1919 in the engineering department of the former American Sheet and Tin Plate Co. He became assistant superintendent of the Shenango works in 1937 and the same year was transferred to the Irvin works as head of the tin finishing department. He was named assistant general superintendent there in 1940 and general superintendent in 1947. A year ago he was made assistant general manager of operations. Born in Sweden, Mr. Oberg became a naturalized U. S. citizen in 1911, the same year he joined U. S. Steel in the roll department at Homestead works. Later he was appointed manager of the company's roll and bar hoop division and became manager of sales engineering in 1932. With the formation of Carnegie-Illinois in 1935, he became Pittsburgh district manager of operations, and was made general manager of operations in 1950.

Oliver W. Traux, Jr. was appointed superintendent of industrial relations for the Donora, Pa., steel and wire works of American Steel & Wire Co. Mr. Traux has been associated with this U. S. Steel subsidiary since 1940, except for a three-year period in military service. In his new assignment he fills the vacancy created by the recent retirement of **E. Soles.** Mr. Traux moves to his new position from the post of labor relations supervisor at the same plant. Succeeding him in that post is **Howard C. Boardman,** formerly training supervisor at the company's Cuyahoga works in Cleveland, Ohio.

John G. Munson, who since 1939 has been vice president-raw materials, United States Steel Corp. of Delaware, now merged into United States Steel Co., has retired. For a time Mr. Munson will serve the company in an advisory capacity. The position of vice president-raw materials of United States Steel Co. has not yet been filled. In the organization both the engineering and raw materials function will be under the direction of **M. W. Reed,** an executive vice president of the new company.

Ira G. Sutton was named general superintendent of the Sanderson-Halcomb works of Crucible Steel Co. of America, Syracuse, N. Y. Mr. Sutton, who joined Crucible in Syracuse in 1928, previously was assistant general superintendent of the Sanderson-Halcomb works. He succeeds **R. K. Warren,** who has assumed a new post in the Crucible tool steel sales headquarters in Syracuse.

E. C. Iverson was appointed chief engineer of Towmotor Corp., Cleveland, Ohio. Mr. Iverson had been associated with the J. D. Adams Manufacturing Co., Indianapolis, Ind., in charge of all product design and development.

ALBERT J. BERDIS

HENRY E. WARREN, JR.

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C. B. Kershner has been appointed purchasing agent for the Birdsboro Steel Foundry and Machine Co., Birdsboro, Pa.

Dr. Robert F. Mehl, director of the Metals Research Laboratory and head of the department of metallurgical engineering at Carnegie Institute of Technology, has been named chairman of the Metallurgical Advisory Board of the National Research Council. He will assume his new post immediately.

Norman F. Smith, who has been vice president and general manager of Osborn Manufacturing Co., Cleve-

NORMAN F. SMITH

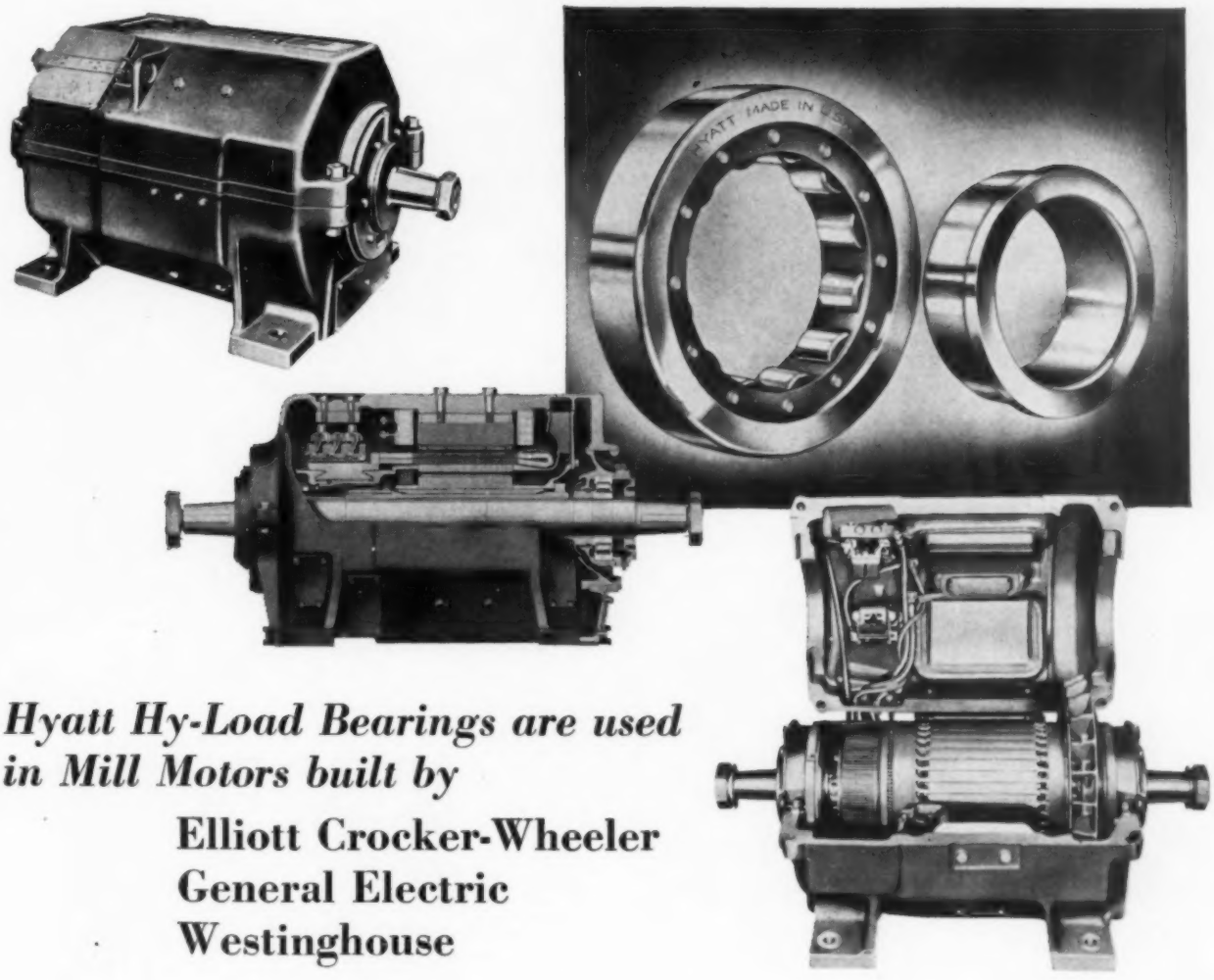
land, Ohio, since 1938, has been elected president. **Franklin G. Smith,** founder and president of Osborn since 1892, was elected chairman of the board.

L. V. Johnson was named chief engineer of National Tube Co., Pittsburgh, Pa. Formerly assistant chief engineer of the company, he will assume the duties han-

L. V. JOHNSON

dled until recently by **John L. Young,** who has been elected vice president-chief engineer of the newly-formed United States Steel Co. Mr. Johnson was born in McKeesport, Pa. He attended the public schools there and also attended Carnegie Institute of Technology. He began working for National Tube during summer vacations at the Christy Park works, McKeesport, Pa. In 1919 he started in the engineering department as a draftsman and served in various mechanical

HYATT Protection for your Mill Motors



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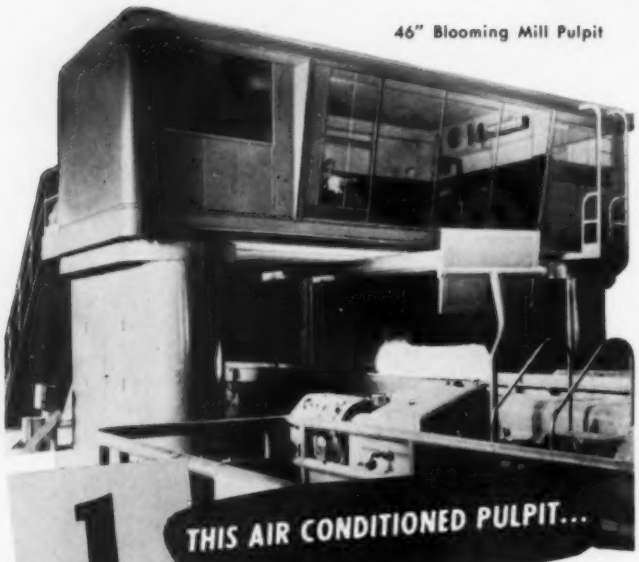
HYATT ROLLER BEARINGS



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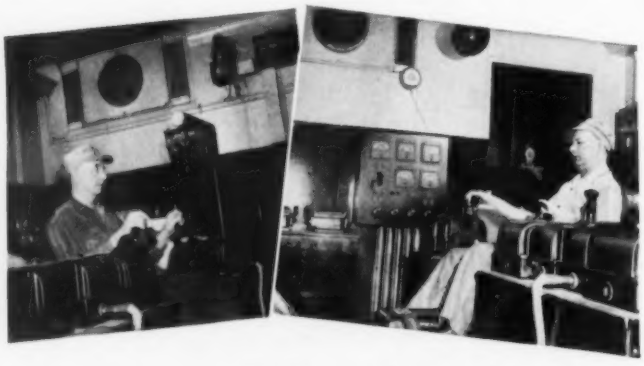
1. THIS AIR CONDITIONED PULPIT...

in a large, modern steel mill enables the operators to do their work with the *alertness* and *skill* expected of them in maintaining capacity production.



Men work most efficiently under these conditions.

2. A UNIFORM TEMPERATURE OF 70-80° ...

is maintained by the Lintern Aire-Rectifier. The air (cleaned and cooled) enters through the rugged, all copper cooling coils located above the men's heads; the *water-cooled* condenser is in one of the columns, easily accessible. Maintenance is a minor item. The Aire-Rectifier pays for itself over and over again in both quality and quantity of work. *Ask for Bulletin AC-149 and tell us your problem so that we can write you fully.*

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and engineering capacities, becoming chief engineer of the plant in 1940. On June 1, 1941, he was promoted to assistant general superintendent of the plant, becoming general superintendent in 1945. Later in 1945, Mr. Johnson became chief project engineer of the company's new specialties plant at Gary, Ind. In April 1948, he was made assistant chief engineer of National Tube Co.

Neal J. Crain was advanced to the position of director of purchases, and **John C. Utzig** to the position of purchasing agent for United Engineering and Foundry Co., Pittsburgh, Pa. These appointments followed the

NEAL J. CRAIN

recent death of **G. Walter Sanborn**. Mr. Crain has been associated with the company since 1914. He has been

JOHN C. UTZIG

purchasing for 37 years, originally as an invoice clerk, later becoming a buyer, and from 1938 until his recent appointment has been the company purchasing agent. Mr. Utzig, likewise, is an old timer at United. Since beginning his association in 1923, originally employed as clerk and accountant in the treasury department, he has been a buyer in the purchasing department from 1930 until his present appointment as purchasing agent.

Robert F. Rentschler was appointed vice president assigned to special duties of Birdsboro Steel Foundry and Machine Co., Birdsboro, Pa. **James M. Heppenstall**

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For Example:

WITH FARREL ROLL GRINDERS——Reports from users indicate that the latest type Farrel machines regrind rolls in record time. In addition, they find that the rolls are accurately ground with a perfect surface free from marks of any kind. Faster grinding means increased productive capacity of the machine and lower labor cost per roll ground.

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INFORMATION and engineering consultation regarding any of the products mentioned on this page are available, without obligation.

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has been appointed treasurer, and **Lester E. Leinbach** is the new secretary.

Robert O. Thomas was appointed open hearth division superintendent at Homestead district works of U. S. Steel Co. Mr. Thomas started at the plant in 1933 as a metallurgical observer. He was named chief metallurgist in 1940, 45-in. slabbing mill superintendent in 1942, and assistant to the general superintendent the following year. He became chief inspector of the plant

R. O. THOMAS

18 months later, and in January, 1949, was named assistant superintendent of the slabbing and plate division. Six months later he became superintendent of that department.

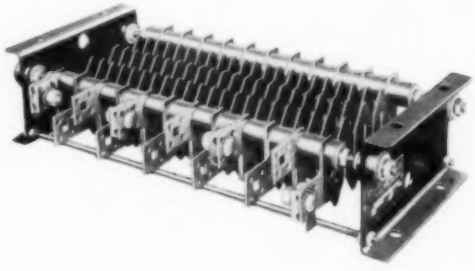
John V. Dorman was named superintendent of fuel and power division at Homestead district works of U. S. Steel Co. Mr. Dorman started at Homestead in 1934 as a metallurgical observer. Two years later he

JOHN V. DORMAN

was transferred to the structural division where he held various supervisory positions. In 1940 Mr. Dorman was appointed assistant superintendent of the structural division and he became assistant to the general superintendent of the plant in 1949.

Donald F. Deakin has joined Atlas Mineral Products Co., Mertztown, Pa., as water and sewer products director. Mr. Deakin is a graduate of Penn State with a degree in civil engineering. **Newton O. Duncan, Jr.** a recent graduate of Texas A & M College has joined

The welded grid assembly is shown here as a unit resting on narrow iron straps above its end frame, support rods, and spacers.



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Bulletin 942-A
TAB-WELD Plate Resistors

The alloy-steel used in these plate resistors has negligible resistance-change between cold and maximum working temperatures. In section form, the EC&M TAB-WELD design *maintains the original OHMIC value* of the section, unlike that of any other resistor section. TAB-WELD Resistor Sections are unequalled in that they do *not* depend upon end-clamping nut pressure for a continuous electrical path.

Also, there's *no burning* in concealed areas—at grid-eyes or at tap-plates. Note, too, the convenience of the tap-plates—welded in position. To shift the external lead-wire, only the terminal-block need be moved. The terminal-blocks are grooved to accommodate several sizes of wire, or flat-bus may be bolted to the terminal-plates.

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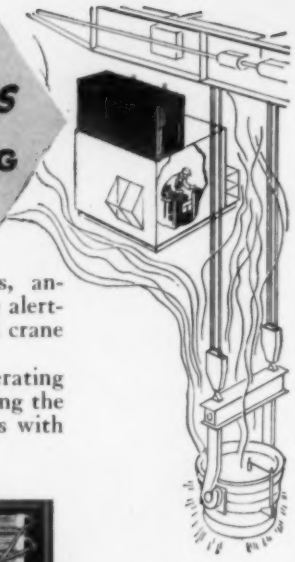

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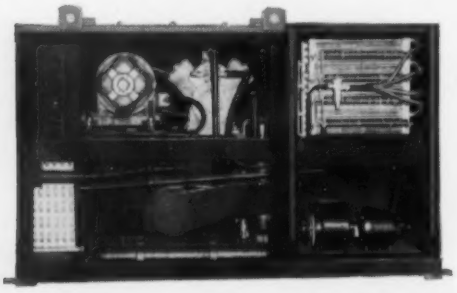
● You can eliminate these crane operating hazards by completely air conditioning the cabs on all types of hot-metal cranes with Dravo Crane Cab Coolers.



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- **FALCON COOLING PLATES**, both Bosh and Inwall—because they are made without those leak producing anchors and chaplets.
- **FALCON PLATES** are all cast without anchors and chaplets—one homogeneous casting with uniform wall thicknesses.

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- **FALCON PLATES** are free from sand inclusions and metal oxides.
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Atlas and has been assigned to the Houston, Tex., office.

William L. Hunter, formerly general manager, has been named vice president and general manager of the Northern Equipment Division, Continental Foundry & Machine Co., Erie, Pa.

John W. Price, Jr., has been appointed assistant to general superintendent of Homestead district works of U. S. Steel Co. Mr. Price started at the plant in 1937

JOHN W. PRICE, JR.

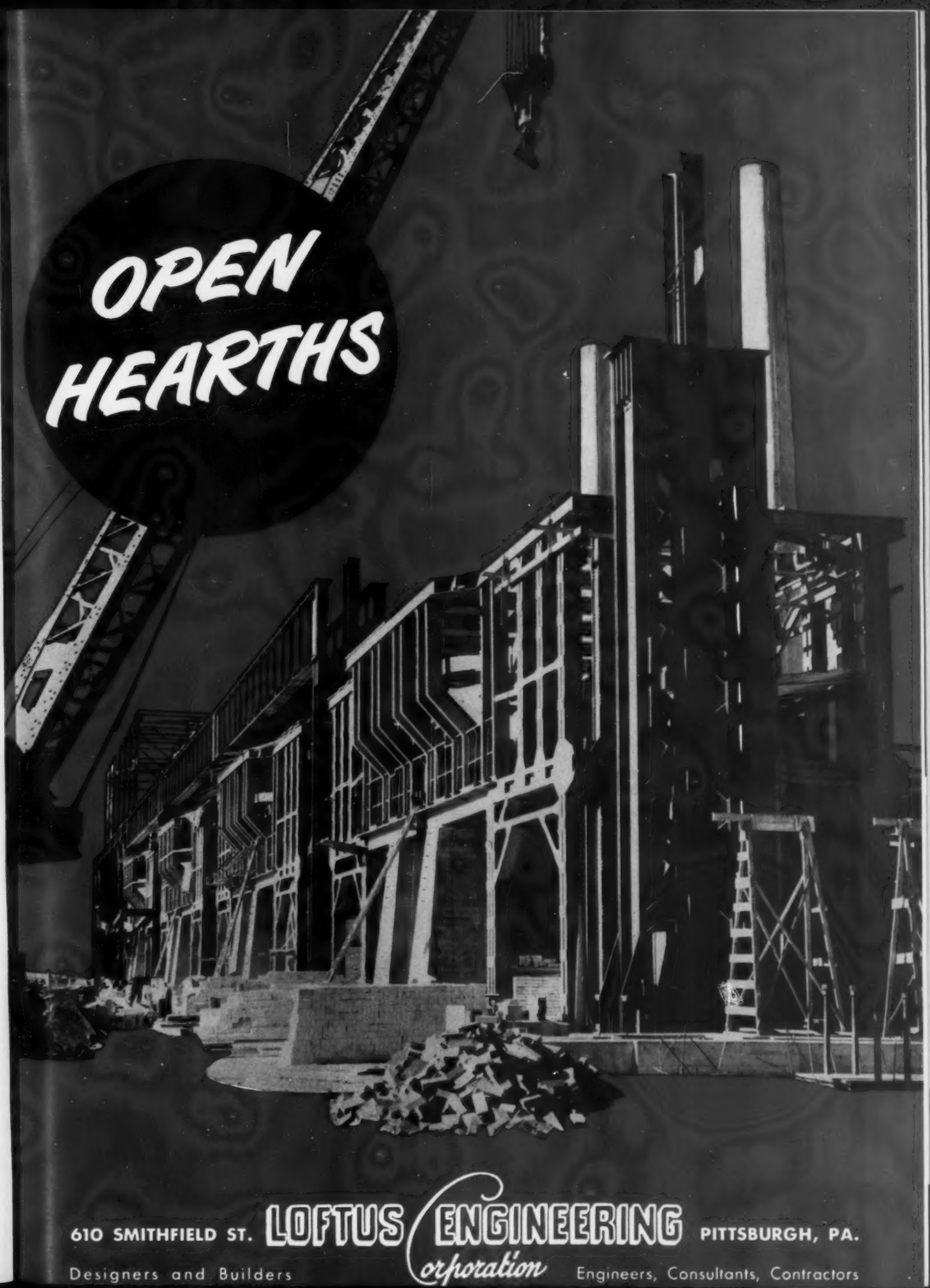
as a metallurgical observer and was appointed assistant chief metallurgist after several promotions in that department. He was transferred to the company's general offices in Pittsburgh in 1945, where he was assistant metallurgical engineer in the railway materials and commercial forgings division.

William E. Crouch, Jr. was named superintendent of

WILLIAM E. CROUCH, JR.

the slabbing and plate division at Homestead district works of U. S. Steel Co. Mr. Crouch began with U. S. Steel in 1933 as a clerk in the metallurgical department at Homestead. He held various positions there until his transfer in 1938 to the slabbing and plate division. He was named superintendent of the plant's 160-in. plate mill in 1943, and was named assistant superintendent of the slabbing and plate division in January, 1949.

John C. Koch was appointed vice president in charge of sales of the Conoflow Corp., Philadelphia, Pa. Mr.



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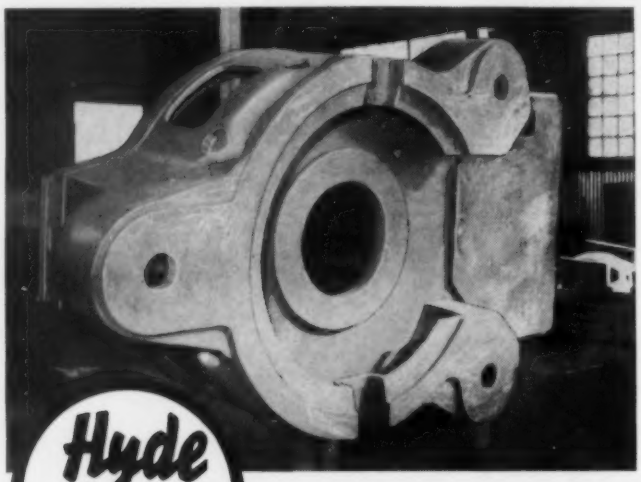

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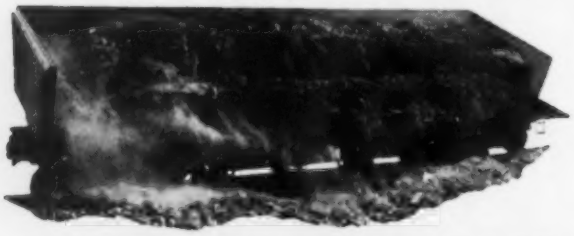

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World's Largest Producer of Air Dump Cars

Koch, who joined Conoflow in 1945, has been acting in the capacity of general sales manager until his recent promotion.

George P. Wilson, Jr., formerly manager of the control section, engineering and construction division of Koppers Co., Inc., was named director of the coke division of the Defense Solid Fuels Administration. Mr. Wilson has been granted a leave of absence by Koppers.

C. S. Beattie has been appointed executive vice president and general manager, and **R. E. Anderson** has been

C. S. BEATTIE

named senior vice president of Delta-Star Electric Co., a division of H. K. Porter Co., Inc. Messrs. Beattie and Anderson were also elected directors of the new Delta-Star Electric Co.

John A. Petroskas was named chief metallurgist of Midvale Co., Philadelphia, Pa. Mr. Petroskas was graduated from Massachusetts Institute of Technology and has had a wide experience in ferrous metallurgy, both in operations and in research. His former employers include Jones and Laughlin Steel Corp., the U. S. Army Ordnance Department, Worth Steel Co., and before going to Midvale, staff metallurgist at Electric Storage Battery Co.

L. G. Graper, formerly superintendent of steel production for Wisconsin Steel Works, a division of International Harvester Co., was named technical advisor for Lone Star Steel Co., Dallas, Tex. Mr. Graper is already on the job assisting with plans for the early start of construction on Lone Star's new steel mill.

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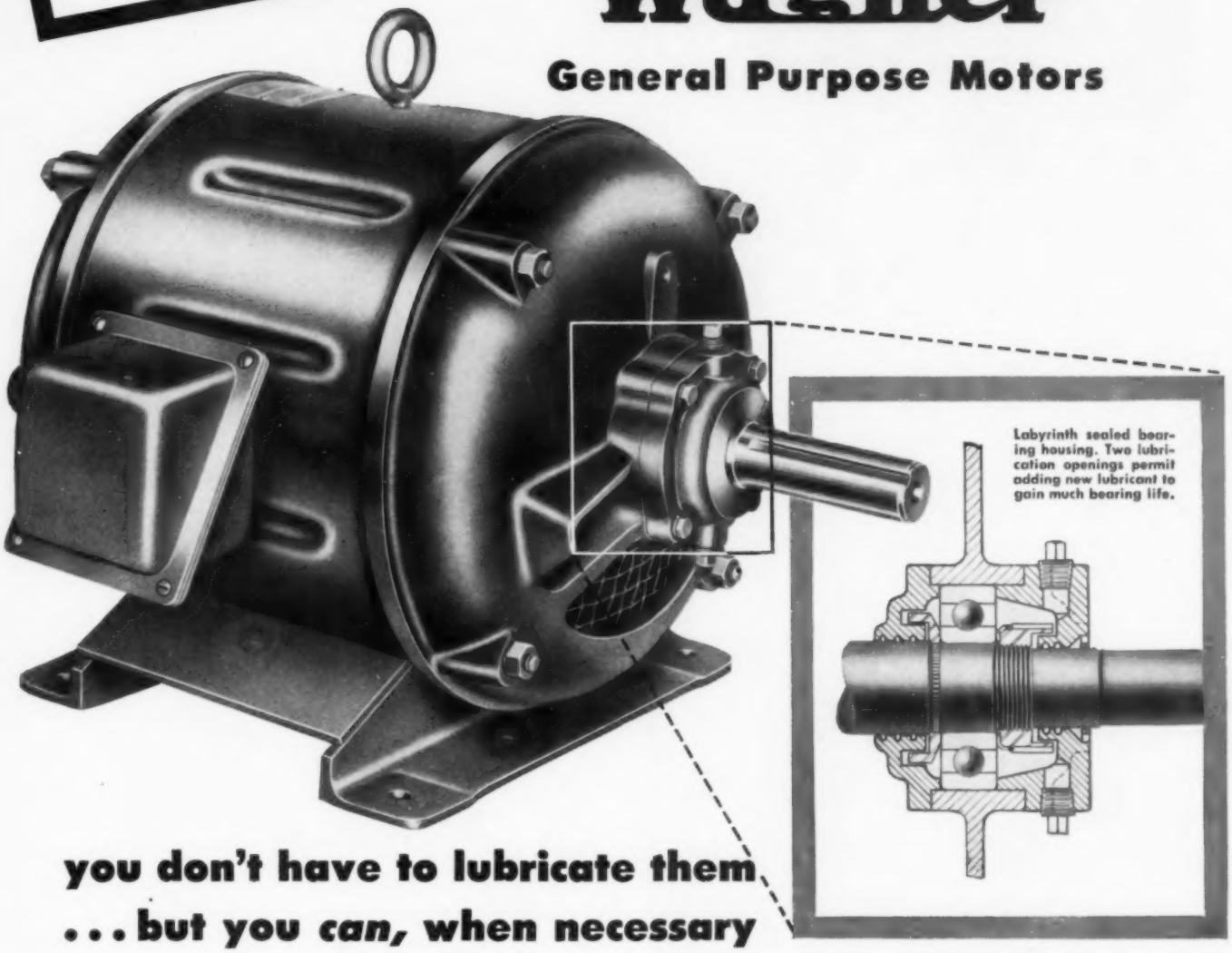

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... but you *can*, when necessary

Wagner Steel-Frame Motors have been *proved*—durable, dependable and trouble-free by more than twenty years of hard usage in industry after industry. They have a reputation for long, useful life. Among the many engineering features that have built this reputation is the ample sized, sealed, bearing housing.

Wagner bearing housings are effectively sealed against the entrance of dirt or grit that cause rapid wear. You don't have to lubricate the bearings (motors in the smaller frame sizes will often operate for the life of the unit without lubrication) but, Wagner Motors are provided with two lubrication openings—you *can* lubricate them, to add much useful motor life where the motors are used in tough applications.

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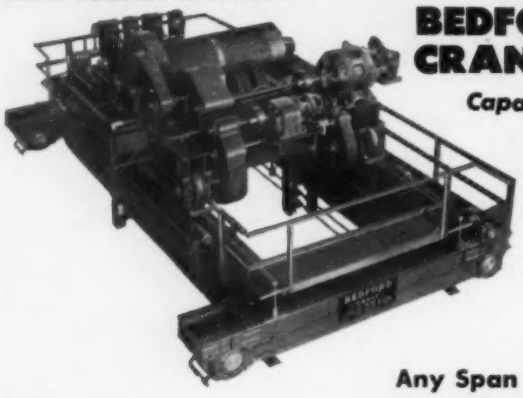

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John C. Redmond, formerly research director of Kennametal, Inc., Latrobe, Pa., has been elected vice president in charge of metallurgical development.

Samuel A. Ott was appointed superintendent of melting for Midvale Co., Philadelphia, Pa. Previous to his association with the Dacor Co., which he left to join Midvale, Mr. Ott had worked with Phoenix Iron Co., Follansbee Steel Corp., and the Penn-Ohio Steel Corp.

Robert W. Snowdon was appointed plant manager of the recently-acquired New Brighton, Pa., works of the Heppenstall Co. The New Brighton plant was formerly owned by the William Leard Corp.

William R. Murdock has recently been appointed manager of application engineering for Trion, Inc., McKees Rocks, Pa. He was previously associated with the American Chain and Cable Co., as a sales representative. Prior to that he was employed by industrial products sales division of B. F. Goodrich Co., Akron, Ohio.

K. C. Gardner, Jr., vice president in charge of operations for United Engineering and Foundry Co., was elected a member of the board of directors and of the

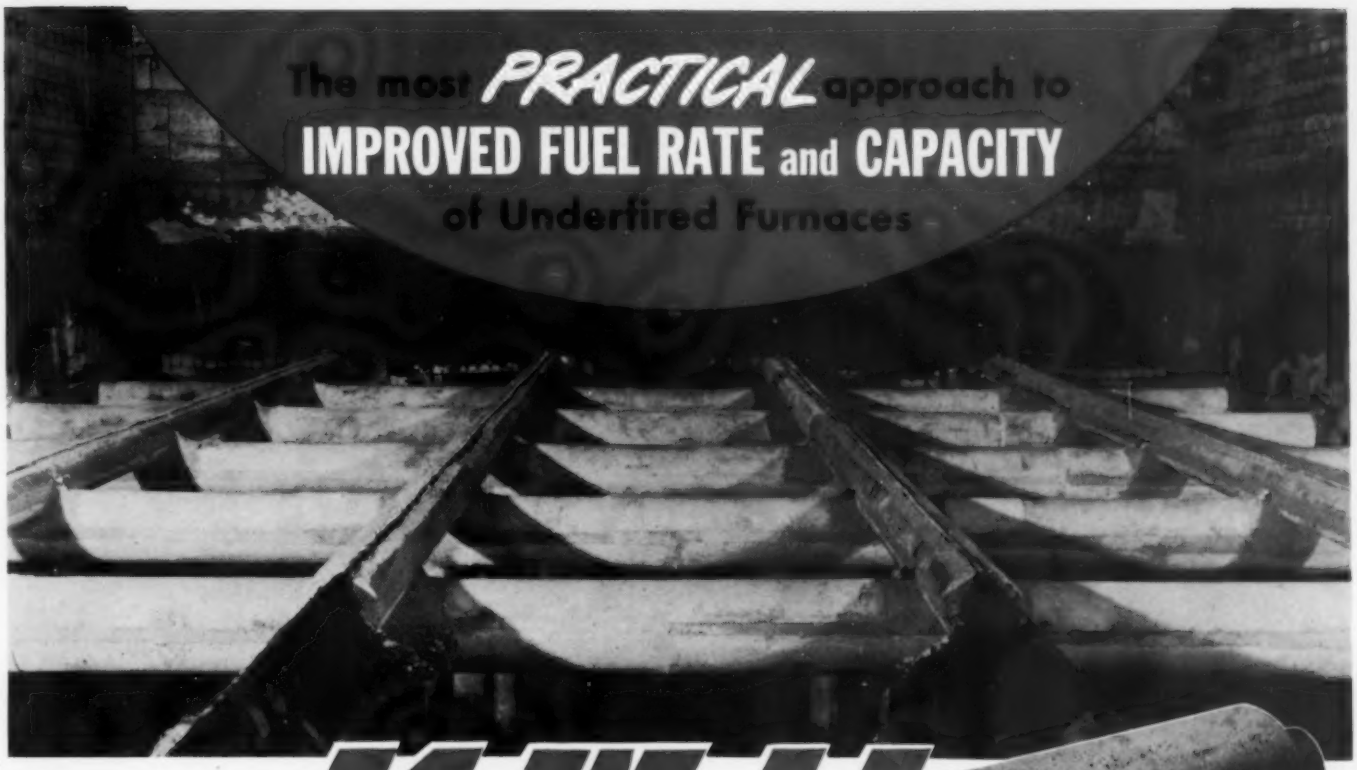
K. C. GARDNER, JR.

executive committee. **C. W. Correll** was elected to the office of assistant treasurer.

John W. Belanger of Schenectady, N. Y., and **Nicholas M. DuChemin** of Lynn Field, Mass., have been named general managers of the large apparatus divisions and small apparatus divisions, respectively, of the General Electric Co.'s apparatus department.

David C. Prince, vice president of the General Electric Co., has been named by **Ralph J. Cordiner,** president, to the president's staff, with special duties as assigned. **Harry A. Winne,** vice president in charge of engineering policy, has been assigned responsibility, formerly held by Mr. Prince for the G-E general engineering laboratory, at Schenectady, N. Y. Concurrently, the appointment of **Ernest E. Johnson** to the newly-created post of general manager of the laboratory was announced. Mr. Johnson had formerly been manager of engineering, large apparatus divisions, of the G-E apparatus department. All three men will continue to have their headquarters in Schenectady.

W. R. Schuchman, chairman of the board of the Homestead Valve Manufacturing Co., Coraopolis, Pa., has retired from participation in the daily operation of



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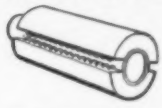
PRECAST, REINFORCED PIPE INSULATION

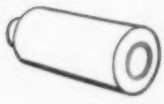
Any furnace change that will save 35,000 cu. ft./hour of natural gas is deserving of serious consideration by furnace operators. Bloom *Ka-Weld* precast, reinforced pipe insulation has brought about such a saving, thereby reducing the demand upon stack, burners and fans—and making possible a 20 tons per hour increase in furnace capacity! Steel is heated more uniformly, skid marks are practically eliminated and slag is greatly reduced.

Made from durable, precast refractory material reinforced with alloy wire mesh, Bloom *Ka-Weld* is easy to install and guaranteed to give satisfactory service. It is manufactured in workable lengths, and can be installed by regular maintenance crews.

Precast lower half section is held in place by welding exposed mesh to pipe.



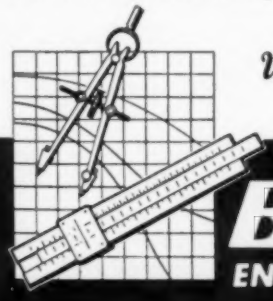
Similarly, the upper half is applied and welded.



The space between the halves is filled with castable refractory.

Skid pipes, crossovers and support pipes of underfired furnaces may be completely protected and insulated by KA-WELD Precast Pipe Insulation, thereby reducing fuel rates, increasing furnace capacity and improving steel quality.

Write for Bulletin 2183



BLOOM
ENGINEERING CO., INC.
857 W. North Avenue Pittsburgh 33, Pa.

WAKE UP
sluggish
BTU's
in your
FUEL
OIL
with

DACAROL THE IDEAL FUEL OIL TREATMENT

for { Greater BTU release
Sludge prevention and removal

Facts and Figures show:

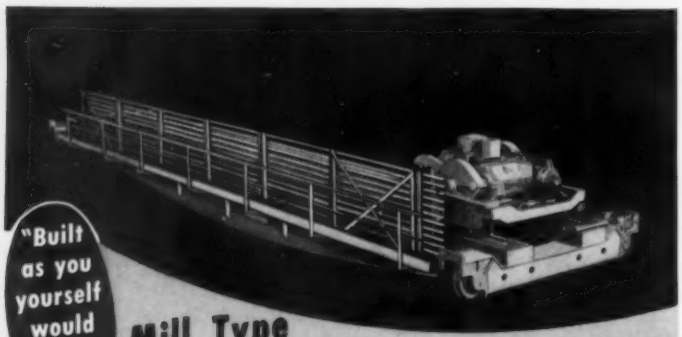
Savings in fuel oil cost and increased production with DACAROL!

DARMOLD THE MOLD COATING of the FUTURE-NOW!

of prepared coatings
THE MOST WIDELY USED FOR INGOT MOLDS

Odorless Vapors — Permanent Suspension
Ready for Use — Eliminates Mixing

DACAR CHEMICAL PRODUCTS CO.
McCARTNEY ST. PITTSBURGH 20, PA.



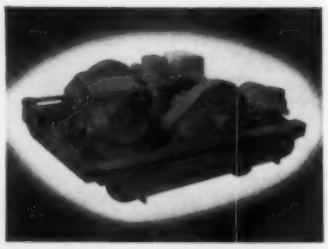
"Built as you yourself would build them"

Mill Type Cranes BUILT BY *Browning*

HAVE *Strength* WHEREVER STRENGTH IS NEEDED

Satisfying A.I.S.E. specifications, Browning Mill Type Cranes incorporate types of motors and controls on which you have standardized. This flexibility suits your VRB crane *perfectly* to your needs. Our design, springing from 49 years' experience, places plenty of strength where it is required.

Ask for our Bulletin "E"



Husky 10-ton mill type trolley equipped with separate load girt for easy removal.

VRB

VICTOR R. BROWNING & COMPANY, Inc.
BOX 309, WILLOUGHBY (CLEVELAND), OHIO
Designers and Builders of Electric Overhead Traveling Cranes and Hoists and Electric Revolving Cranes

the business after 49 years continuous service. Mr. Schuchman became identified with Homestead Valve in 1902; was made general manager in 1905 and president in 1921, which position he held until he was elected board chairman in 1949. Mr. Schuchman, however, will continue to function as chairman of the board of directors.

Robert L. Pettibone was named chief metallurgical engineer of Sintercast Corp. of America, Yonkers, N. Y.

Richard E. Coe was named assistant to the president of Electric Furnace Co., Salem, Ohio. Mr. Coe was formerly connected with Electric Furnace in the capacity of fuel engineer and more recently has been associated with the North American Mfg. Co. as a district manager.

W. A. Neumann, Jr. was named manager of the IMO-De Laval products division, of De Laval Steam Turbine Co., Trenton, N. J. In this capacity Mr. Neumann will be responsible for the engineering and sales of the company's line of power transmission equipment and rotary pumps. He has served as acting manager of this division for the past year. In addition to his new responsibilities, Mr. Neumann will continue as assistant treasurer. He previously held the position of controller.

Obituaries

Walter Geist, 56, president of Allis-Chalmers Manufacturing Co., Milwaukee, Wis., since May, 1942, died January 29.

Joseph C. Faix, superintendent, ground rod department, Copperweld Steel Co., Glassport, Pa., died January 15.

John Avery, president of Roots-Connersville Blower Corp., Connersville, Ind., since 1946, died January 13.

Fred H. Loftus, 56, died unexpectedly February 10 in his home at 236 Parker Drive, Mt. Lebanon, Pittsburgh, Pa. Mr. Loftus was president of the Loftus Engineering Corp. and its subsidiaries, the Loftus Construction Corp. and Loftus Contracting Corp. He was a graduate in mechanical engineering from the University of Iowa and during his long career in the field of industrial engineering developed and patented many improvements for the steel industry.

Before forming the Pittsburgh firms, he was chief engineer, secretary and a director of the Open Hearth Steel Furnace Co. and later was general manager and a director of the Vulcan Furnace and Equipment Co.

During World War I he was commissioned as a first lieutenant in the Air Force.

Annual Spring Conference

DETROIT, MICHIGAN
HOTEL STATLER
APRIL 30 - MAY 1

OVER 9 MILLION TONS AND STILL IN SERVICE!

A WORLD'S RECORD FOR "TOOL STEEL" PROCESS SCREW DOWN SCREWS ESTABLISHED ON 46" BLOOMING MILL AT INLAND STEEL CO.

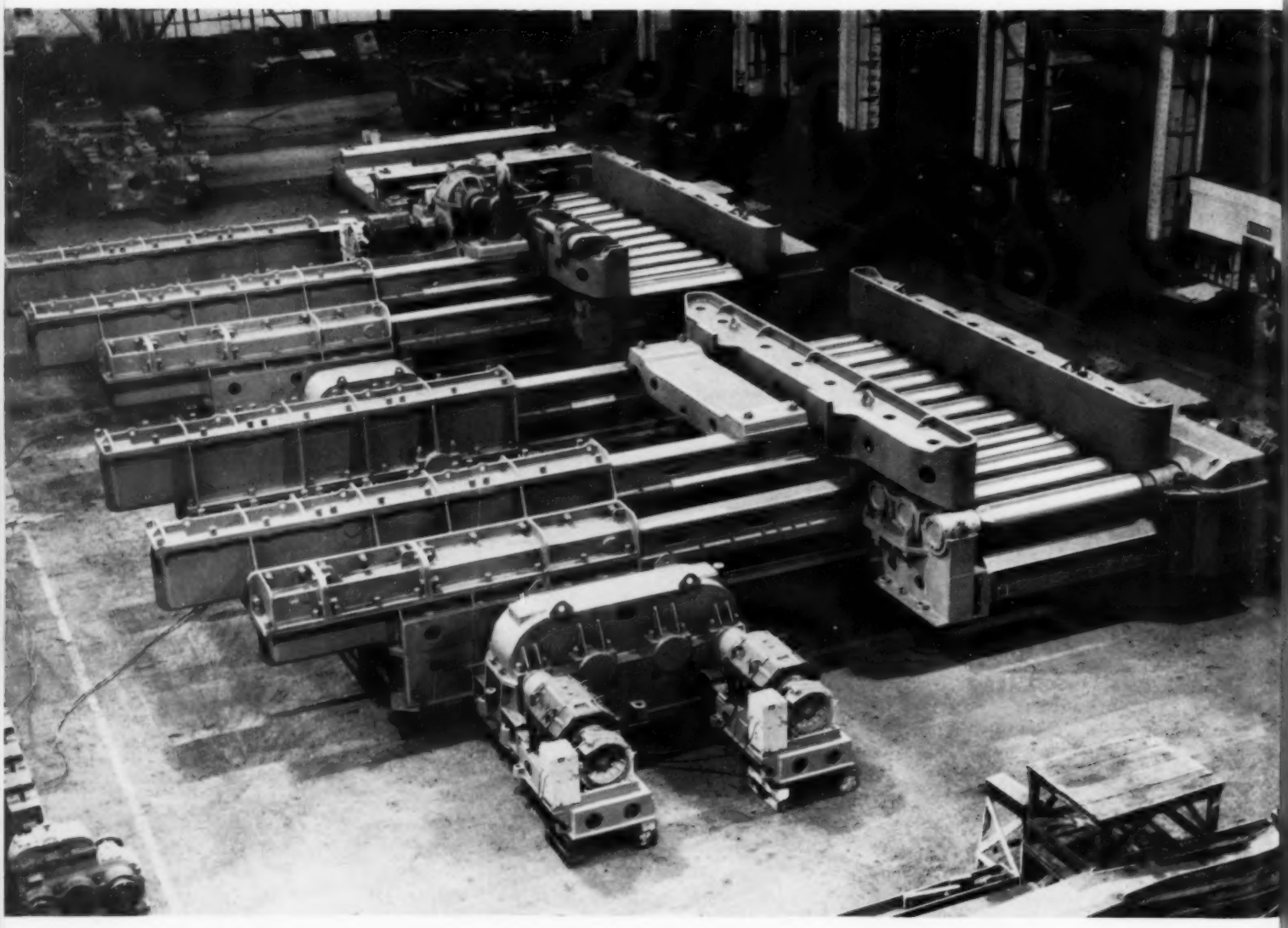
"TOOL STEEL" PRODUCTS ARE GUARANTEED TO GIVE LONGER LIFE THAN ANY OTHER PRODUCTS IN THE SAME SERVICE!

WRITE TODAY FOR COMPLETE INFORMATION.

THE TOOL STEEL GEAR & PINION CO.
CINCINNATI 16, OHIO, U.S.A.

BUILT BY MORGAN Engineering

40″ BLOOMING MILL TABLES AND MANIPULATOR



Shop view of 40″ Blooming Mill Manipulator and Mill Tables, furnished with a Morgan 40″ Blooming Mill, having Twin Motor Drive. Manipulator is of the overhead type, electrically driven with retractable heads so the table rollers can be removed without dismantling the manipulator heads.

Table girders are of cast steel box section type with integral oil trough on drive side. All gears are totally enclosed, operating in oil, and have hardened teeth. All bearings are of anti-friction type, lubricated through a centralized motor operated system.

Your inquiries appreciated.

THE MORGAN ENGINEERING CO.

ALLIANCE, OHIO. PITTSBURGH—1420 OLIVER BUILDING

DESIGNERS • MANUFACTURERS • CONTRACTORS • BLOOMING MILLS • PLATE MILLS • STRUCTURAL MILLS • ELECTRIC TRAVELING CRANES • CHARGING MACHINES • INGOT STRIPPING MACHINES • SOAKING PIT CRANES • ELECTRIC WELDED FABRICATION • LADLE CRANES • STEAM HAMMERS • STEAM HYDRAULIC FORGING PRESSES • SPECIAL MACHINERY FOR STEEL MILLS

Equipment News...

THREE NEW ANTI-RUST PAINTS ARE DEVELOPED

▲ Addition of three new specially chromated anti-rust paints to its "Rustrem" line of maintenance coatings is announced by Speco, Inc.

Known as "Rustrem Chromate Special," the new paints are available in clear, black and aluminum. They possess all of the penetrating and sealing qualities of standard "Rustrem" which has been used for many years by industry. In addition they contain liberal quantities of chromate pigment which, according to the manufacturer, is in itself, an efficient rust inhibitive.

The new paint was produced to meet widespread requirements for an extra effective anti-rust paint, the manufacturer's announcement states. It is reputed to stand up longer under extreme conditions of temperature and moisture than any previously available anti-rust paint.

THREAD INSERTS SOLVE MAINTENANCE PROBLEM

▲ The maintenance department serving one of New York City's subway lines has the frequent problem of replacing worn and stripped threads in the axle-cap bolt holes of its subway car motor-frame castings. Repair of these holes is expedited by the use of stainless steel helical-wire thread inserts.

These inserts permit the use of the same size cap screws in the repaired holes as were used in the original holes. This eliminates the matching operations that would be necessary if oversize threads and cap screws were used to solve the damaged thread problem.

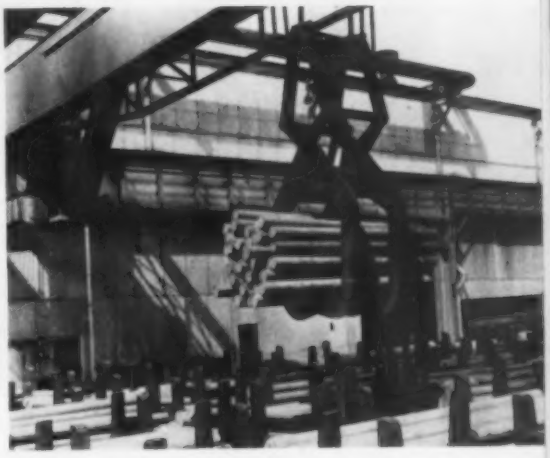
Thread repair is accomplished in the following manner: the damaged thread is cleaned out with a drill slightly larger in outside diameter than the major diameter of the original thread; the hole is retapped using an oversize, special-threaded tap; and the helical thread insert is installed.

Threads in the motor frame shown in Figure 1 were repaired in this manner. This casting had a badly worn thread, (A), a completely stripped thread, (B), and a broken 2¼-in. cap screw, (C). Original holes had $1\frac{9}{32}$-7 tapped threads.

After removal of the broken stud, these three holes were repaired by: (1) drilling out with a $1\frac{21}{64}$-in. drill, (2) tapping with a special oversize Heli-Coil tap identified with a $1\frac{9}{32}$-7 marking, and (3) installing a stainless steel Heli-Coil thread insert, (Figure 2), to bring the hole back to size. This insert, having a diamond-shaped cross-section, has threads on its outside diameter conforming to the special tap and internal threads conforming to the original $1\frac{9}{32}$-7 thread.

The entire operation was completed in approximately 55 min. The formed wire inserts, Figure 3, provide smooth threads that permit frequent assembly and disassembly operations with a minimum of thread wear. Also, corrosion caused by infiltration of water or other reactive liquids and

TONGS SPEED LOADING



Mill designers, engineers and operators at the Lorain, Ohio, plant of National Tube Co. assisted in the development of automatic tongs which enable the craneman alone to handle loads of rolled steel rounds weighing up to 30,000 lb. A unique automatic locking device contained in the tongs, made by Heppenstall Co., allows the crane operator to pick up, transport and deposit batches of rounds from 4-in. to 13-in. in diameter without a hook-up man or crane follower. Since ground crews are not needed, no difficulties can result from misunderstood signals, premature lifts and loosely attached slings.

The tongs pictured are at work in the Lorain works rounds storage yard at the No. 4 blooming mill.

FIGURE 1

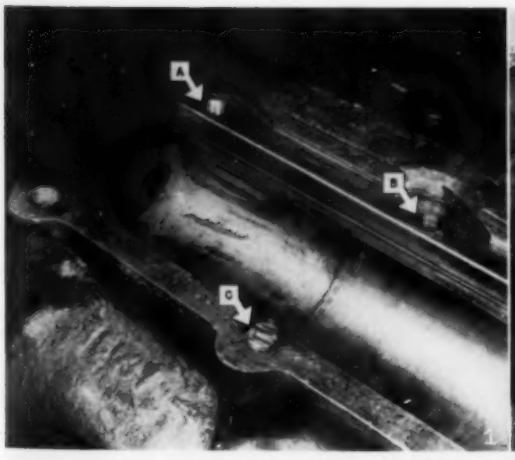


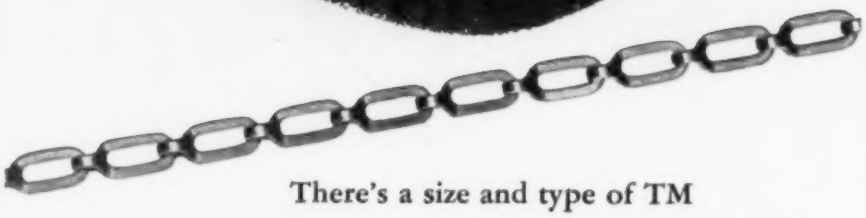
FIGURE 2

FIGURE 3

TM CHAIN

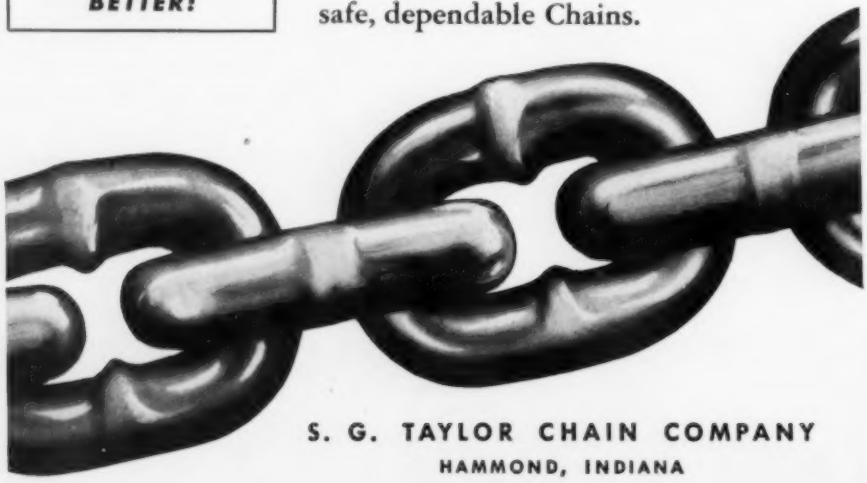
a complete line!

.. of Safe Dependable Chain for Every Job!



There's a size and type of TM Chain to fit each of your requirements. Choose from Proof Coil, BBB, Steel Loading, Hi-Test, Alloy Steel, Dredge Iron, Conveyor, Machine, Coil, Side, Truck, Passing Link, Well, Anti-Spreader, Trace, Furnace, Champion Weldless, Jack (single or double), Pump or Sash Chain. See your mill supply distributor or send coupon today for details on any of these safe, dependable Chains.

Each does a definite job— BETTER!



S. G. TAYLOR CHAIN COMPANY
HAMMOND, INDIANA

S. G. TAYLOR CHAIN COMPANY
Dept. 5
Hammond, Indiana
Please rush details on _____ chain.

Name _____

Address _____

TAYLOR MADE
A GREAT NAME IN
Chain SINCE 1873

gases will not cause deterioration of these threads.

The superior strength of the 18-8 stainless steel more than compensates for the loss of material in the bolt-hole boss, (C). Increased loading strength is achieved because the helical insert automatically adjusts itself to mating threads on both the casting and the stud, thereby distributing the load properly over each thread.

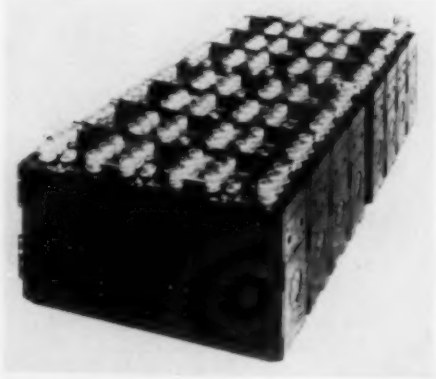
NICKEL CADMIUM BATTERY REDUCES MAINTENANCE

▲ A new T-Type nickel cadmium alkaline battery, designed specifically for starting railroad diesel engines and manufactured by Nickel Cadmium Battery Corp., makes it possible to save as much as 100 man hours a year per locomotive, because of reduced maintenance. It is also lighter in weight than conventional batteries and requires no additional space or alteration in existing battery racks.

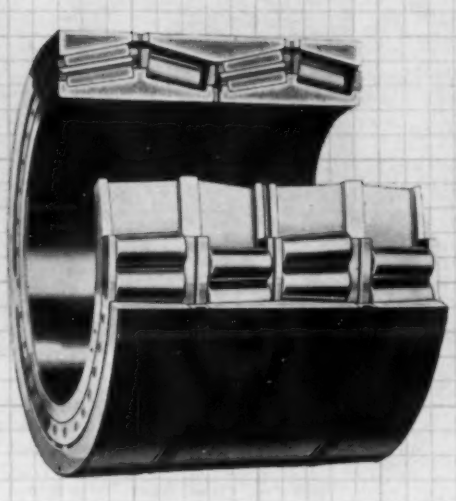
The battery is available in two capacities: Model THR-30, 142 amp hours, in 8 6-cell trays, which is interchangeable with 17-plate, 284 amp hour conventional batteries, and Model THR-44, 210 amp hours, which is interchangeable with 25-plate, 426 amp hour conventional batteries. Model THR-30 weighs 1825 lb and Model THR-44 weighs 2675 lb.

One of the most outstanding features of the T-Type battery, in addition to interchangeability, light weight and minimum space requirement, is the inherently long life characteristics of the nickel cadmium type of battery and its maintenance of capacity even after years of severe

Savings of 100 man-hours per year per locomotive were effected by using nickel cadmium battery.



for continuous strip production...

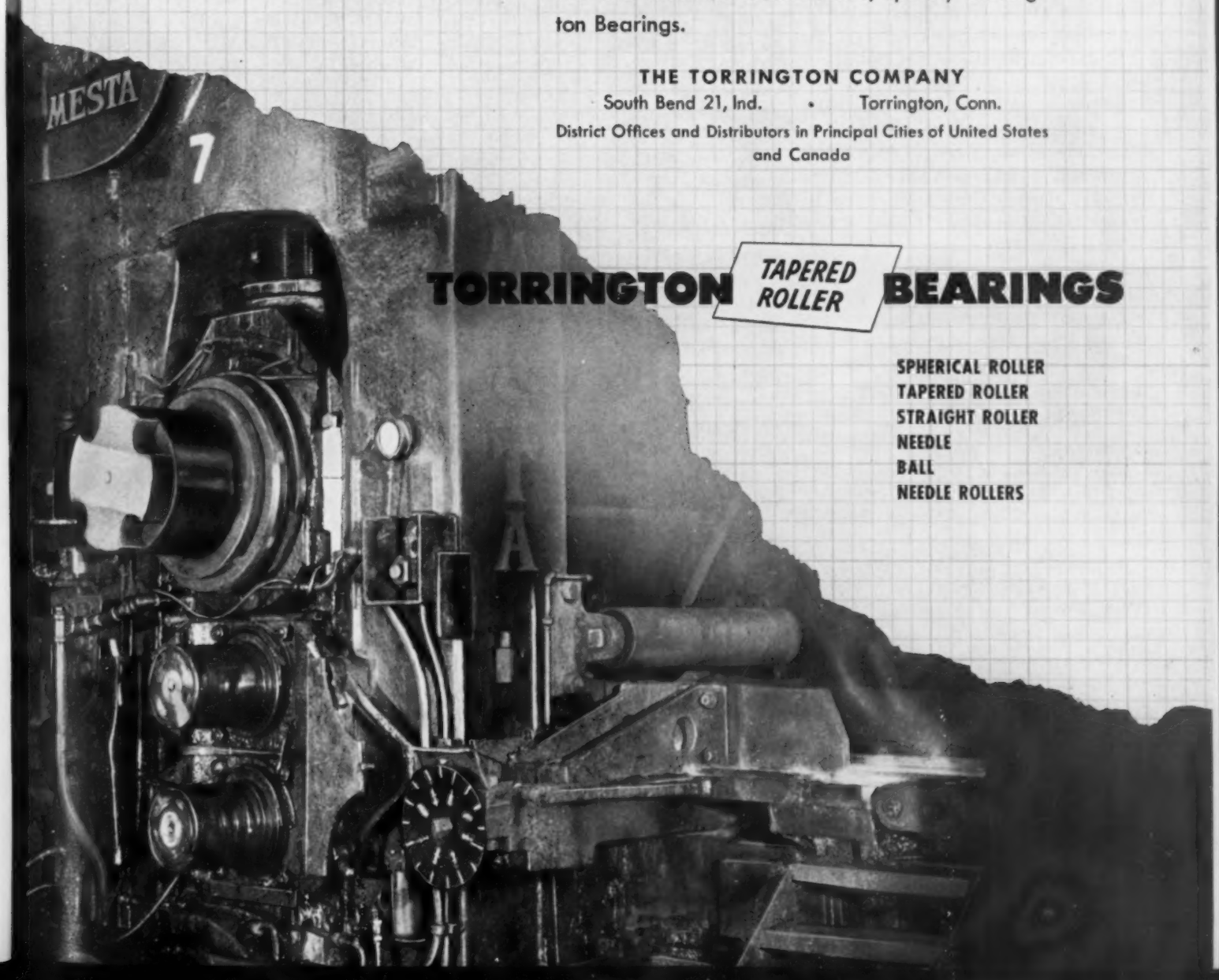


Torrington Roll Neck Bearings handle extreme radial and thrust loads to assure continuous high-speed production in this 68" hot strip mill.

Four rows of closely-spaced tapered rollers in Torrington Roll Neck Bearings provide extra load-bearing capacity. The reduced cross-section permits larger roll neck diameters for greater mill strength and rigidity. The low starting and running friction of Torrington Bearings allows rapid acceleration and constant speed producing more uniform gage.

For reliable mill operation and long service life with minimum maintenance, specify Torrington Bearings.

THE TORRINGTON COMPANY
South Bend 21, Ind. • Torrington, Conn.
District Offices and Distributors in Principal Cities of United States and Canada



TORRINGTON TAPERED ROLLER BEARINGS

SPHERICAL ROLLER
TAPERED ROLLER
STRAIGHT ROLLER
NEEDLE
BALL
NEEDLE ROLLERS

use. Containers, cells and plates are of steel construction.

Among those factors that play an important part in the reduced maintenance costs of Nicad batteries are (1) their all-steel construction which eliminates breakage, (2) their ability to be overcharged without damage, which overcomes one of the common causes of lead battery failure and (3) their negligible water consumption. The T-Type battery can also be charged with standard charging equipment at trickle, normal, or high rates; overcharging will not harm the battery.

ROTARY SWITCH HAS SOLID SILVER CONTACTS

▲ A new rotary selector switch announced by Leeds & Northrup Co. for use in instrument circuits has solid silver contacts and totally enclosed construction. Contact resistance is about 0.001 ohm, and changes less than 0.0005 ohm on life tests of 10 million operations.

Stationary contacts are made of solid silver, no plating to wear off. Brushes are multiple-leaf, self-aligning, made of durable silver alloy. Thermal emf when switch is operated at normal speed is less than one microvolt, making the switch suitable for low-level circuits.

Electrical strays are exceptionally low. Maximum inductance is less than 0.03 microhenry, and capacitance between segments is less than 0.5 micro-microfarads. Insulation withstands 500 volts rms between segments and from segments to ground.

Current interrupting capacity, tested for 100,000 operations, is one ampere at 110 volts, 60 cycles on resistance load. Contacts carry continuous current of 5 amperes.

Adjustable detent permits variation of switching torque. Switch is a shorting type, and is designed for 2-hole panel mounting per JAN and RMA standards. Various switching combinations are supplied, from single-pole 12-position to 6-pole 12-position.

USE THE
ENGINEERING MART

RAM TRUCK CAN CARRY 80,000 LB OF STEEL

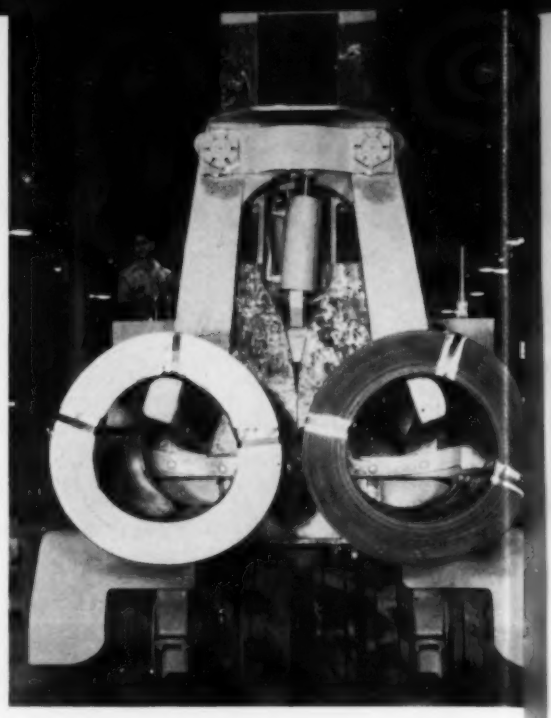
▲ The completion of an 80,000 lb capacity industrial lift truck was announced January 26 by Yale & Towne Manufacturing Co.'s Philadelphia division. Built for the steel industry, this giant truck is designed to slash handling time, hike output, and increase quality of cold rolled strip steel now in critical supply.

Weighing-in at 84,000 lb, the new Yale truck is powered by a unique diesel-electric unit of the same size used in a 25-ton locomotive. On the front of the truck are two huge, snout-like rams that open and close like a scissors. These unique rams provide, for the first time, a unit that can carry one large coil of steel or two smaller ones. It is the first of a new series of ram and fork trucks now available in capacities from 20,000 lb to 100,000 lb.

At a preview of the new truck held for production executives of the steel industry, Elmer F. Twyman, vice president in charge of Yale's Philadelphia division, said: "The need for this equipment was made evident after the recent introduction of continuous wide strip mills which roll coils of steel at speeds in excess of 5,000 fpm. These mills have been found to be capable of rolling faster than material could hitherto be supplied or carried away. This truck, which will now permit the increase of coil sizes from today's normal 30,000 or 40,000 lb coils, to 60,000 or even 80,000 lb coils, will help solve this difficulty."

At the present time, 17 per cent of the entire rolling time for coils is often consumed in handling, according to operation statistics from one large steel producer, it was demonstrated by Mr. Twyman. He also pointed out that by doubling the size of the coils handled, steel mills will not only slash the handling time per pound of steel, but also improve the quality and yield per coil, since the ends of coils rolled while the strip mill is accelerating and decelerating are, for the most part, "off-gage" and rejected.

Other new engineering features of the Yale ram truck are the dual controls and narrow construction of the lifting channels which provide the utmost visibility for the operator.



This huge ram truck was built for the steel industry. It was designed to slash handling time, hike output, and increase quality of cold rolled strip steel now in critical supply.

Also, despite the fact that the loaded weight of the truck will exceed 150,000 lb, only a fingertip touch on the steering handle is necessary to actuate the hydraulic system that turns the wheels.

DEVICE GIVES CLEAN-CUT EDGES OF STEEL PLATE

▲ Air Reduction Sales Co. has announced the availability of a new plate-edge preparation device. This device has been designed to increase production and insure clean-cut, accurate preparation of plate edges. Its ability to cut a single or double bevel accurately, with or without a land, recommends it especially for use in shops or factories which do any amount of steel fabrication work.

The preparation device which employs a spring-balanced, free floating carriage and caster-wheel assembly to permit bevel cutting over plate undulations while maintaining a constant tip-to-work distance, may be mounted on any gas cutting machine equipped with a 3 in. square torch bar.

Torches may be individually positioned vertically or laterally without changing the bevel angle. Fuel and preheat pressures are initially set with individual torch valves, and once set, the master valve controls

piping repairs *cost more* now!

You make them less often

by using Dependable Quality

CRANE VALVES

...That's why more Crane Valves are used than any other make

No. 488 Iron Body Clamp Gate

easy access prevents trouble with this valve

Remove just two nuts to dismantle this gate valve for inspection, cleaning, or repairs—without taking it from the line. Reassemble just as easily, knowing that Crane clamp design keeps the bonnet joint snug and accurately aligned. Use Crane Clamp Gates on steam, water, and air, but especially in heavy fluid lines needing periodic cleanout. They'll save time, labor, and encourage regular servicing that prevents valve trouble.

Combining easy access with highly dependable service features, Crane Clamp Gates typify Crane Quality—*better valve performance at lowest ultimate cost.*

CRANE

CRANE CO., *General Offices:*
836 S. Michigan Ave., Chicago 5, Ill.
Branches and Wholesalers Serving All Industrial Areas

VALVES • FITTINGS • PIPE • PLUMBING • HEATING

turning-on and shutting-off gas supply without disturbing settings of the individual torch valves.

TAR BASE COATING IS ANTI-CORROSIVE

▲ "Steelsaver," a high-gloss, coal tar protective coating, which has been field tested for the past twelve years, under numerous corrosive conditions, is now being produced in quantity. This was announced by Continental Coatings Corp.

The coating is one of six coal tar base, anti-corrosive coatings manufactured by Continental Coatings Corp. and formulated to protect metals, woods, masonry and insulations. Continental coatings form a tough, elastic film which resists the penetration of chemicals, fumes, moisture and heat. They are non-soluble in oil and are completely waterproof.

Steelsaver is presently protecting air ducts, coke ovens, condenser coils, cranes, gas holders, rolling stock, steel work, tank exteriors, and valves.

No primer is needed. The coating may be dipped, sprayed or brushed. One gallon covers approximately 500 sq ft of smooth surface. It dries dust-free to a high gloss in less than three hours. It maintains its protective properties in dry heat up to 500 F. For thorough protection, two or more coats may be needed.

Steelsaver protects in direct ratio to film thickness and number of coats applied. It resists strong inorganic acids and strong alkali, ranging from sulphuric acid to caustic potash. It also protects against alcohol, formaldehyde, salt spray, a wide variety of organic acids and other chemicals.

TENSION ACCOMPLISHED WITH AIR PRESSURE

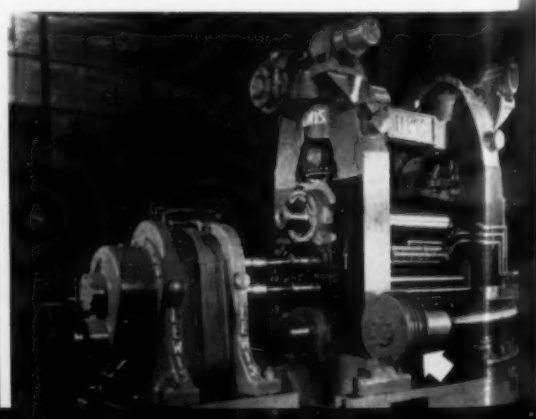
▲ Scrap losses and machine downtime due to foil breakage are being practically eliminated by a new precision tensioning means used on aluminum foil mills built by Lewis Foundry and Machine division of Blaw-Knox Co.

The new tensioning control is based on use of a novel high capacity low pressure air brake manufactured by Linderman Devices. Tension produced by this brake can be precisely calibrated against air pressure and controlled by an air valve. No separate air supply is required—ordinary factory line compressed air being adequate.

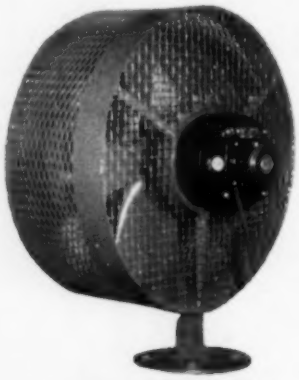
The problem of changing tension requirements as the coil is dereeled is taken care of by the operator who simply adjusts the air pressure to the brake according to a calibration chart.

The Linderman brake's precision of control is largely due to the fact that the brake is free from any self-energizing action. Braking power is directly proportional to the applied air pressure and possible variations

Tension produced by this brake can be precisely calibrated against air pressure and controlled by an air valve.



IS HEAT SLOWING UP YOUR WORKMEN?



TRUFLO CRANE CAB FANS
For cooling interiors of crane cabs and other confined areas. Adjustable both horizontally and vertically. Four blade type, 12 and 18 in. sizes.

Keep them COOL with TRUFLO FANS

TRUFLO PORTABLE COOLING FANS
Easily portable. Help keep efficiency high where work is hottest. 12 to 36 inch diameters.

Production suffers when workmen are overheated. Steps begin to drag, efficiency falls.

Now, when speedy production is vital, Truflo Fans can help keep your workmen on their toes. All Truflo Fans are designed and built correctly to put fresh cool air *in large volumes* exactly where it is needed. Perfectly-balanced shafts and blades give more air per h.p. . . . strong steel frames stand up longer under hard use . . . rugged wire guards protect men against injuries.

All of the following types can help beat the heat, keep production moving in your plant. Write for illustrated literature.

PORTABLE COOLING FANS
CRANE CAB FANS • WALL FANS
EXHAUST FANS • BLOWERS
ROOF VENTILATING FANS
PENT HOUSE FANS

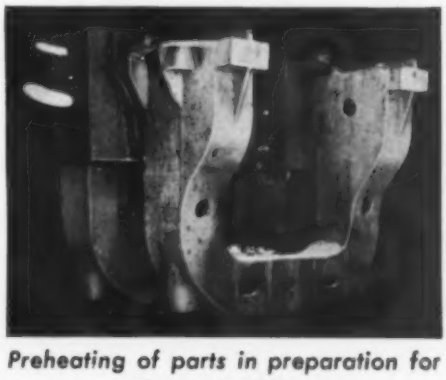
TRUFLO FAN COMPANY
245 MAIN ST., HARMONY, PA.

WHEN A LEADING steel producer undertook to construct a new ingot stripper in one of its major works, the casting of a 50-ton housing posed a problem . . . Limited furnace capacity made it impossible to cast the giant part in one piece.

After consultation between the engineering firm in charge and M & T Thermit experts, it was decided to cast two halves and weld them together with Thermit. Three welds were required: one 32 x 29 and two each 44½ x 24. Approximately 5-tons of forging thermit were used to make the three welds. Among many economies effected, only one-half pattern had to be made.

For efficient and economical fabrication *or* repair, think of Thermit . . . Write for descriptive bulletin. It's packed with facts that may help solve a problem of yours.

Parts of huge housing inverted and aligned for welding.



Preheating of parts in preparation for Thermit Welding.

METAL & THERMIT CORPORATION

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in braking effort are not multiplied by the brake.

LOAD MEASURING UNITS WEIGH COLD STRIP

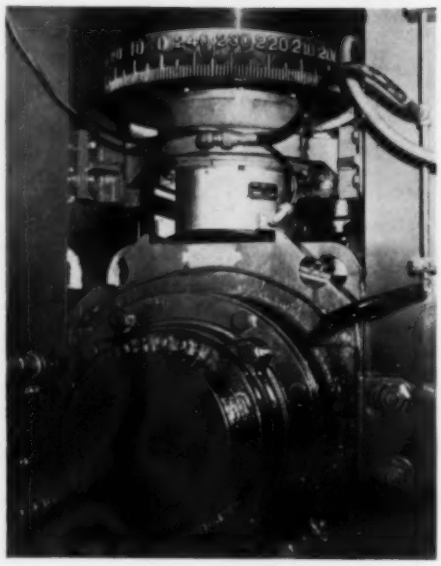
▲To obtain more uniform aluminum sheet products, cold strip rolling mills at the Edgewater plant of Aluminum Co. of America have been equipped with load measuring units incorporating bonded resistance wire strain gages.

With these load weighing devices at each end of the mill rolls, closer control is possible because they provide an accurate, continual indication of roll loads, and load may be adjusted while rolling. This feature permits control of sheet gage as the sheet is being produced, without waiting until a whole length has gone through the rolls. Protection against bearing overloads is also provided.

The mill reduces aluminum strip from ⅛ in. to 0.025 in. Load capacity of the two cells on this rolling mill is 600,000 lb each. An important feature of this force measuring device in rolling mill service is that it has practically no deformation under wide variations of load.

The load measuring unit is essentially a short steel column on which SR-4 strain gages are bonded. Rolling mill load cells are among the SR-4 devices manufactured by Baldwin-Lima-Hamilton Corp. Compression of the column changes the electrical resistance of the fine wire grid of the strain gages, four of which are employed and wired together in the form of a Wheatstone bridge. The load may be measured by any of several types of instruments, including indicators and recorders that may be calibrated directly in pounds or other units.

The load weighing devices are placed at each end of the mill rolls.



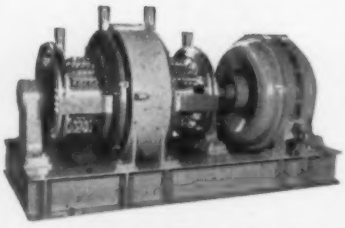
Accuracy of measurement is high and permanent. An overall accuracy of 1 per cent of full scale is guaranteed under normal mill conditions. Load cells are compensated for temperature variations so that they give good reproducible accuracy over a range of plus or minus 50 F from normal operating temperature.

USE STAINLESS STEEL IN GALVANIZING BOATS

▲ Until recently, replacement of equipment used in galvanizing fabricated metal products was a costly problem at the plant of Lehigh Structural Steel Co. A number of materials were used in an effort to increase the useful service life of pickling tanks, boats and yokes. Results

COLUMBIA

MOTOR GENERATORS



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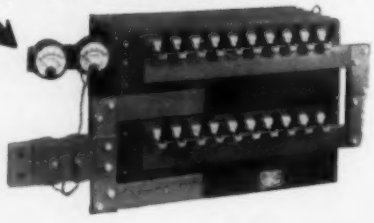

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Galvanizing boats made of stainless steel resist corrosion.

were not satisfactory until a relatively new material, Carpenter stainless steel No. 20, was tried. Some time ago the galvanizing boats and yokes were made from stainless No. 20, and they are still in excellent condition. The material's excellent corrosion resistance is also being successfully used in the drainage system of Lehigh's pickling tanks.

RECORDER MEASURES ROTOR TEMPERATURE

▲ An electronic recorder for accurately and quickly measuring temperature of the rotor in large electric generators has been developed by Minneapolis-Honeywell Regulator Co.

The "ElectroniK" has been designed to provide a better and more economical instrument to assist operators in avoiding overloads, according to Charles W. Bowden, central stations industry manager of the company's Brown Instruments division. In addition, the instrument furnishes a 12-in. strip chart record which can be used as a guide for gradually cooling a generator, Bowden said.

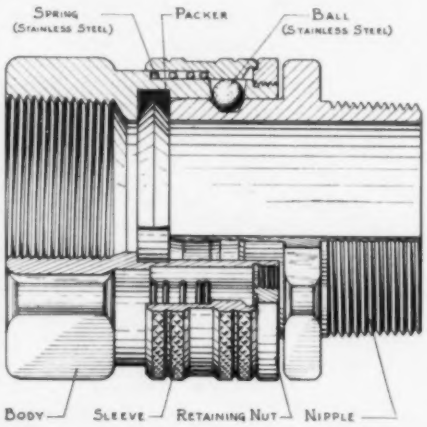
The recorder has a range of 0 to 150 C, a limit error of 1.5 C, a dead zone of 0.3 C, and a pen speed of 1.4 minutes full scale. Its range of rotor winding resistance is 0.1 to 4.0 ohms and it has a dielectric test of 1500 volt rms for one minute.

In designing the new instrument special consideration was given to users who, generating large volumes of their own power, want maximum safety and dependability for peak capacity operation. The recorder is made as a special product with deliveries in about 90 to 120 days from receipt of orders.

ROLL CHANGES SPEEDED WITH HOSE COUPLING

▲ Many steel plants are speeding up roll changes and reducing the labor required by the application of Robb "Quick-Seal" hose couplings, manufactured by the Robb Manufacturing Co.

The principle in which this coupling differs from others is that of packing, which is in the form of an expanding packer of vee-cut type and is put under compression when the two halves of the coupling are joined, expanding as the pressure builds up in the line.



The first coupling, after 2½ years service, is still in service.

Hose life is increased by the full swivel action of the couplings, which will allow the hose to unkink itself easily. These connections are available in any size from ¼ in. up; there is no size limit. They also may be obtained in any metal desired, depending upon the application intended, and in addition they are made in the "block-ell" shape which incorporates a right angle into the connection. Any material that flows through a line may be handled by the coupling, whether hot or cold, at any pressure up to the bursting point of the metal parts. The coupling may be obtained with an automatic shut-off valve built in either side or in both sides.

Many applications have been found throughout steel mills on gas, water, grease, oil and other lines. Any end connections necessary to allow the insertion of the couplings into existing equipment are built right into the parts so that no extra equipment is needed for attachment.

The first coupling, produced and sold about two-and-a-half years ago, is still in operation, and many applications have since been made. Savings have been effected through both the leakproof characteristics and the time-saving factor during roll changes, and such times when it is desired to break connections speedily.

HAND SERRATING TOOL IS SIMPLE TO USE

▲ National Carbon division, Union Carbide and Carbon Corp., now has available an improved hand serrating tool for use with "Karbate" brand impervious graphite pipe. Since Type FC flexible couplings are used in fitting impervious graphite pipe where strong, flexible joints are required, the effectiveness of the joint depends to a considerable extent upon the quality of the serrations on the pipe.

The tool is simple, rugged in design and extremely easy to use, assuring a tight, workmanlike joint in a minimum of time. It provides an advantage over other types of piping since it facilitates quick assembly of "Karbate" pipe on the job site. Pipe sizes from 1 in. to 6 in. inclusive, may be serrated.

NEW PLANT OF YOUNGSTOWN ALLOY CASTING CORP.

Shown is the new plant of Youngstown Alloy Casting Corp. at 168 N. Meridian Road, Youngstown, Ohio. In this plant, modern machinery and production methods are used in the manufacture of "Trantinyl" guides for the rolling mill industry. A new addition is being built to this new plant which will give added production capacity.

5

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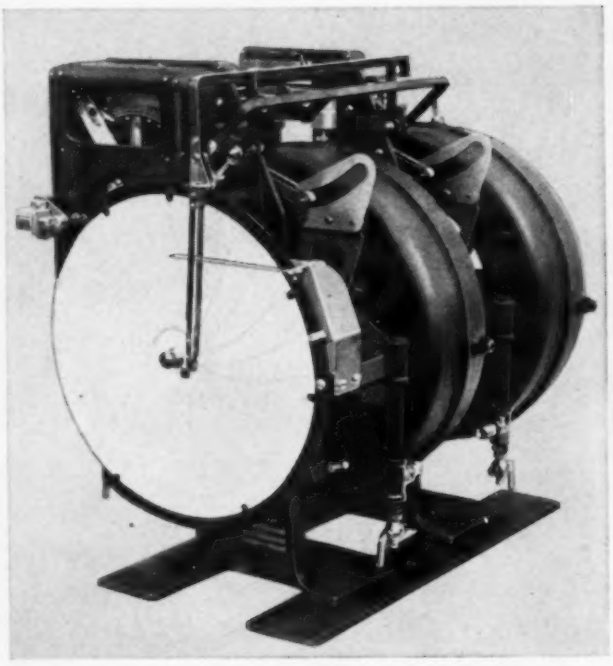

Typical Hagan Ring Balance Dual Flow Meter with two low pressure-low differential rings — for recording and integrating gas flow and recording air flow.

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2 **THEY ARE ACCURATE**—Maximum rate of ring rotation occurs at low flow rates. Ample power to operate recording, integrating and other mechanisms is available over entire scale. High accuracy at low flows is especially advantageous where turndown range is wide.

3 **THEY ARE ADJUSTABLE**—Each ring assembly is adjustable for full scale differential over a range of 7 to 1. Rings are available for a continuous differential measuring range of ½ inch to 420 inches water column.

4 **THEY ARE SIMPLE**—There are no stuffing boxes or pressure tight bearings. No dampening devices are used. Level of mercury, or other sealing fluid, is not critical.

5 **THEY ARE RUGGED**—Design and materials produce precision results throughout a long life, requiring a minimum of personal attention, and costly maintenance.

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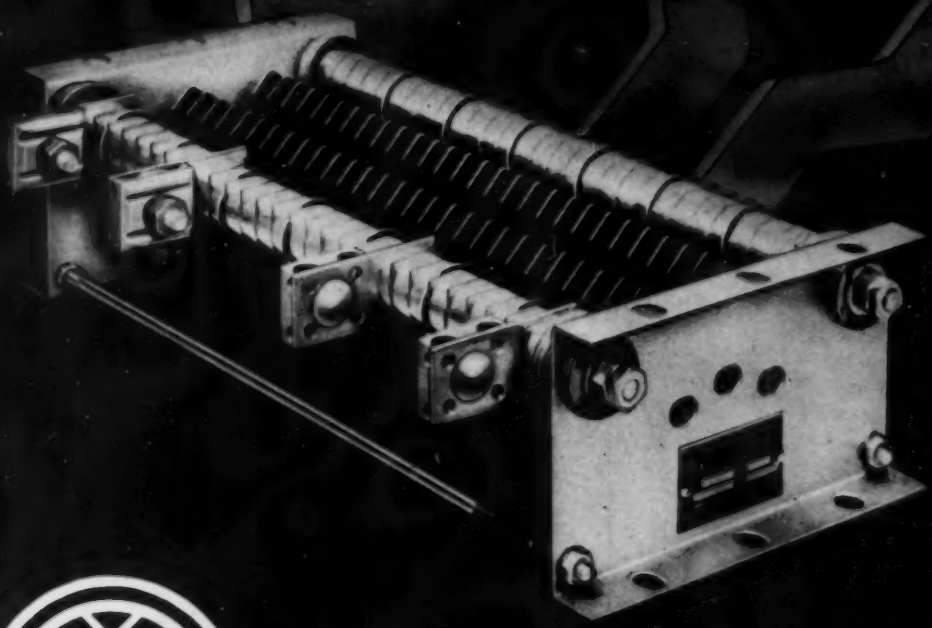

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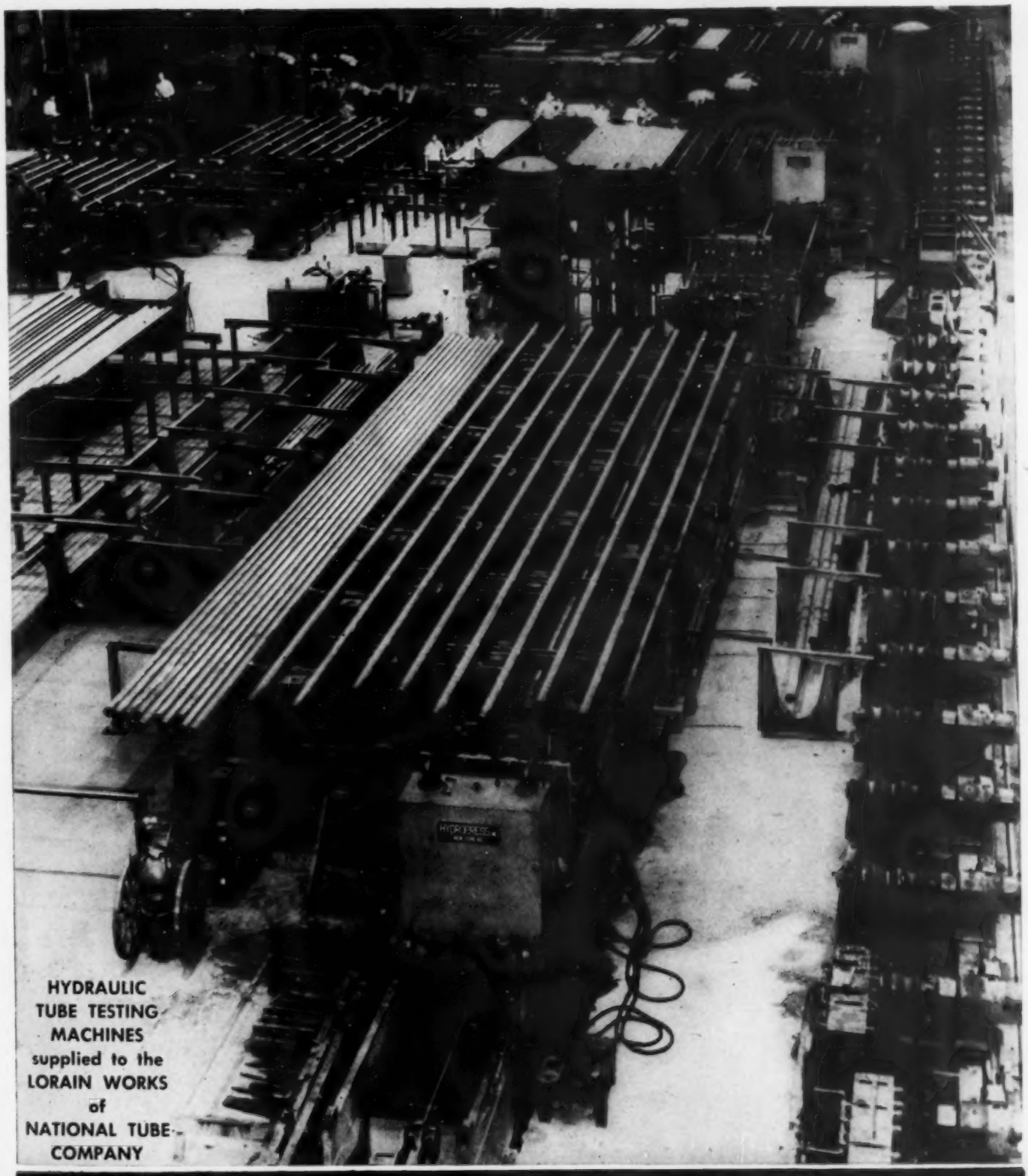

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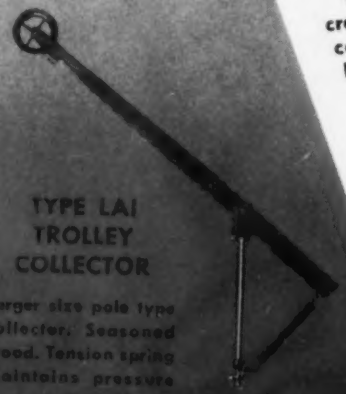

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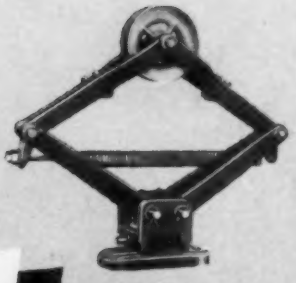

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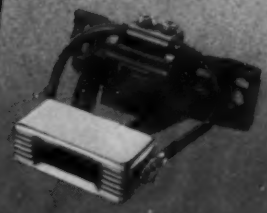

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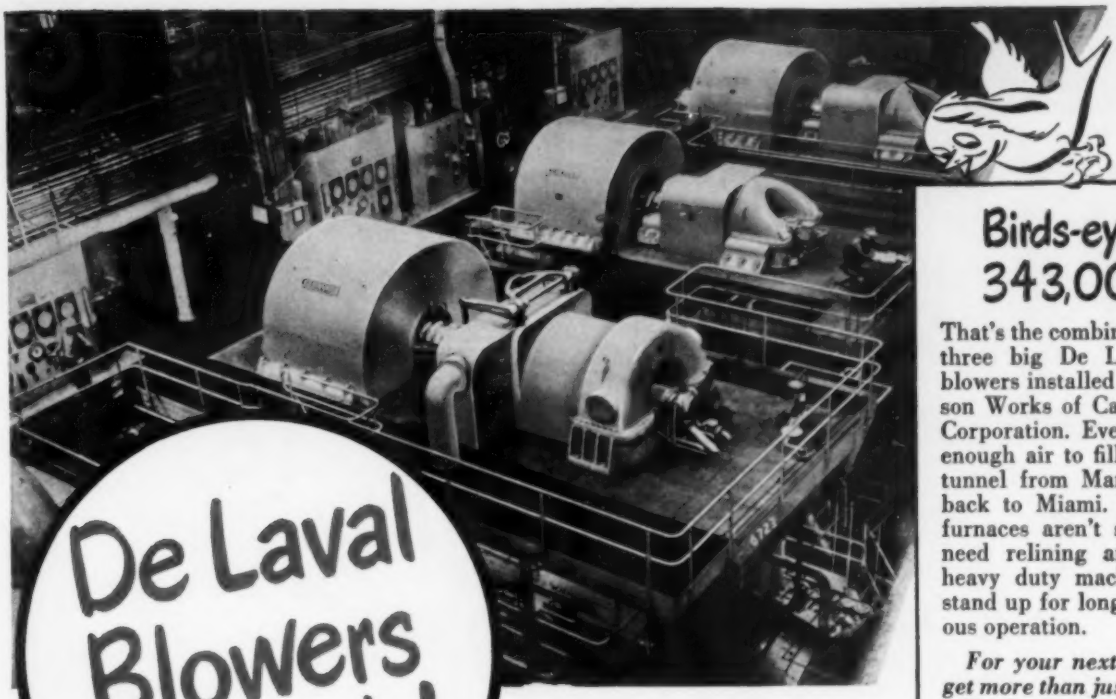
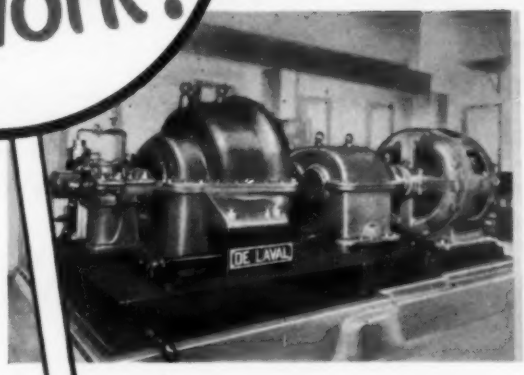


De Laval Blowers at work!

Birds-eye View of 343,000 C.F.M.

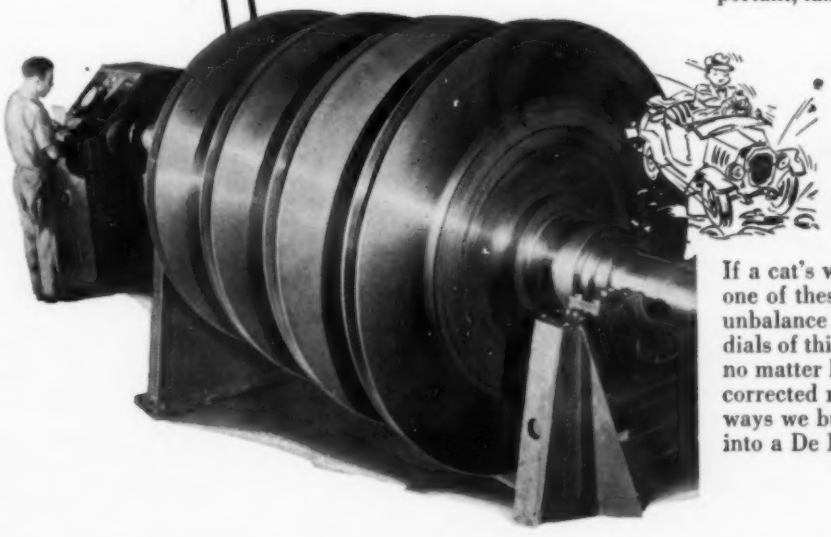
That's the combined capacity of these three big De Laval blast furnace blowers installed at the Edgar Thomson Works of Carnegie-Illinois Steel Corporation. Every day they handle enough air to fill a four foot square tunnel from Manila to Madrid and back to Miami. What's more, blast furnaces aren't shut down till they need relining and it takes husky, heavy duty machines like these to stand up for long periods of continuous operation.

For your next blower, be sure to get more than just a birdseye view of a De Laval unit. Let our engineers show you the whole picture.



They forgot the rule book for this blower!

We would never recommend that a centrifugal blower be opened for inspection only once every 22 years. Yet this De Laval two-stage machine in the Houston, Texas Sewage Disposal Plant was recently opened for the first time since it was installed in 1928 . . . *the blower and gear were in near perfect condition!* Our service man only had to clean up the journals a bit and put the unit back in service. If heavy-duty, continuous service is important, take your cue from this. We build 'em to last.



Stopping vibration before it starts!

If a cat's whisker could hang onto the edge of one of these spinning blower wheels, the unbalance it created would show up on the dials of this dynamic balancer. Any unbalance, no matter how slight, can be detected and corrected right here. This is just one of the ways we build extra years of service into a De Laval blower.

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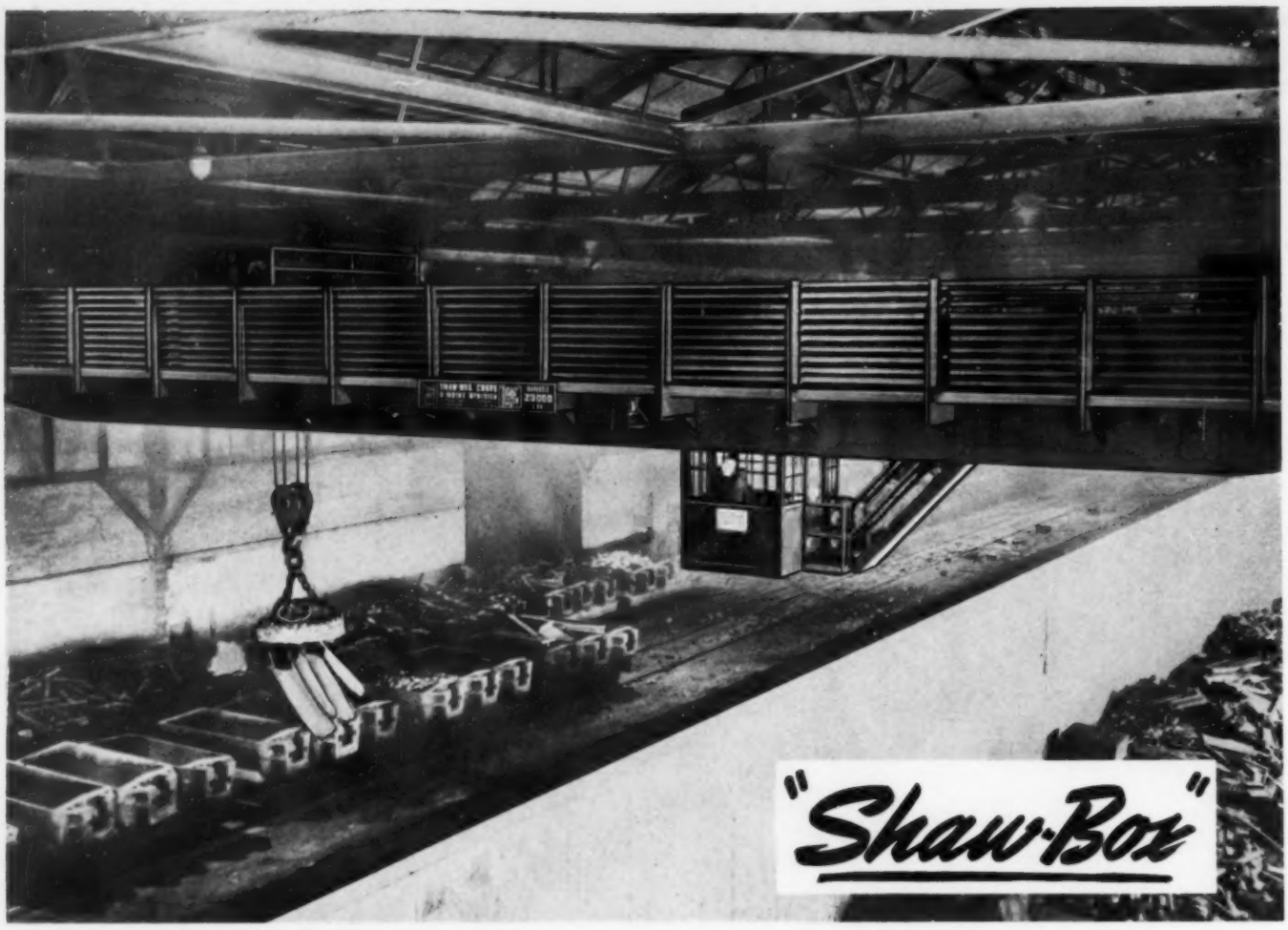

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Book Reviews

▲ **Productivity in the Blast Furnace and Open Hearth Segments of the Steel Industry 1920-1946** by William T. Hogan, has just been published by the Fordham University Press, 22 Park Place, New York, 7, N. Y., 6 x 9 in., 150 pp, price $4.00. This book is of interest to the statistically minded analyst of operations in the steel industry. This study considers the changes in productivity in blast furnace and open hearth operation, physical volume, i.e., man hours per ton, cost production, detailed methods of operation. Advantages and disadvantages of new methods, success in new inventions and adaptations of these are discussed and analyzed in full detail.

▲ **Galvanizing** (Hot-Dip) by H. Bablik, third edition, 502 pp, 306 ill., size 5½ x 8¼ in. has recently been published by E. & F. W. Spon, Ltd., 15 Bedford St., Strand W.C., London, England, price 70/-. This book is a third edition of one of the standard works on this subject, which has been completely rewritten to bring it up to date on recent research and practical experience. The book describes only hot-dip galvanizing as well as related pickling. It discusses in great detail the iron-zinc and fusion reactions which have been developed and covered in great detail. The book is a worthwhile addition to the literature of the operator and engineer of galvanizing equipment.

▲ **Elements of Ore Dressing** by Arthur F. Taggart, 596 pp, 6 x 9 in. has just been issued by John Wiley & Sons, Inc., 440 Sixth Ave., New York 16, N. Y., price $10.00. This book is essentially a text book which is both practical and modern. It emphasizes the analysis of machines and processes as well as the identification of their elements with fundamental scientific laws. Book does not stress structural and operating detail, but emphasizes the methods of flow sheet analysis and considers mills as complete process units.

▲ **Ingenious Mechanisms for Designers and Inventors,** Vol. III, edited by Holbrook L. Horton, 536 pp, 6 x 9 in., 317 Ill. has just been published by the Industrial Press, 148 Lafayette St., New York, N. Y., price $6.00. This is a companion book of the similar Vols. I and II and provides an encyclopedia on mechanisms and mechanical movements selected from automatic machines and various other forms of mechanical apparatus. The cases described give examples of ingenious design which illustrate ideas and principles which are applicable in designing machines and devices which require automatic features or mechanical controls.

▲ **Die Design and Diemaking Practice,** 3rd edition, edited by Franklin D. Jones, 1083 pp, 6 x 9 in., 661 ill. has just been published by the Industrial Press, 148 Lafayett St., New York 17, N. Y., price $7.00. This book is an extensive revision of the previous two volumes, and much new material has been added. The book is a treatise for die makers and die designers. It gives illustrated descriptions of a large variety of selected dies for all kinds of power press operations. Practical information and data on approved practice and construction are given in the book.

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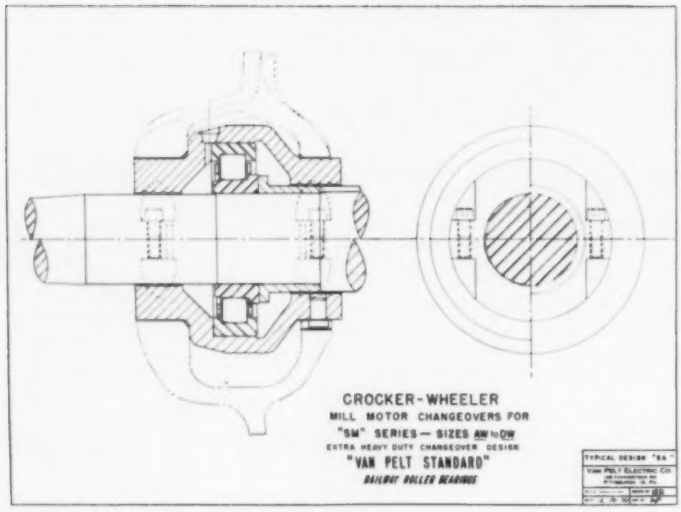
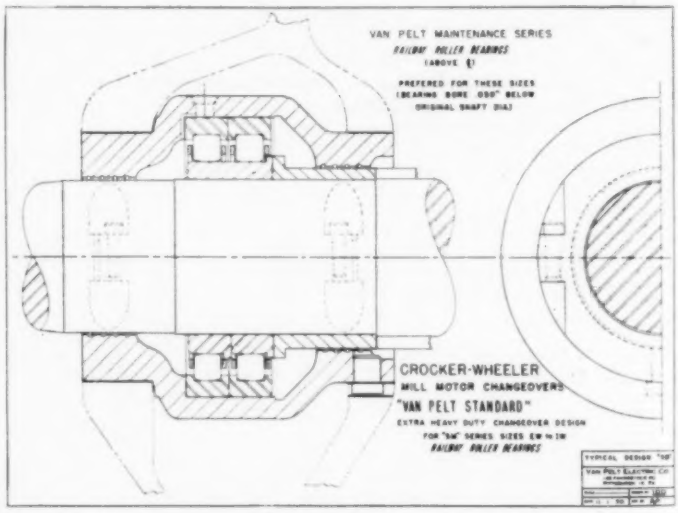
VAN PELT ★ MOTOR ★ CHANGEOVERS

★ *Bearing Changeovers for Crocker-Wheeler Type SM Mill Motors*



Typical of sizes AW to DW Crocker-Wheeler Mill Motors, this design permits the easiest of all changing-over of mill motors. Frame alterations consist of chamfering some sharp corners and preparing slot for dowel pin, additional lugs are desirable on the top and bottom frame halves for better clamping.



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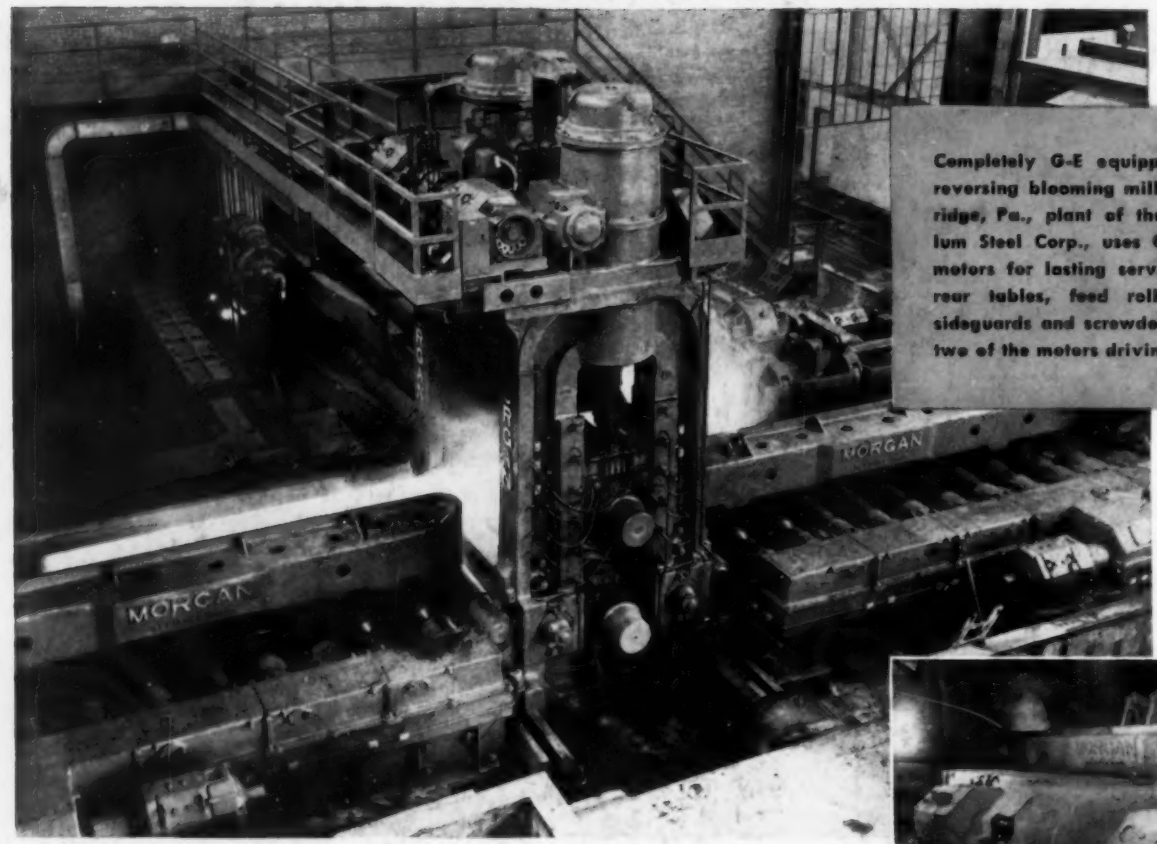

Completely G-E equipped, this 40-inch reversing blooming mill at the Brackenridge, Pa., plant of the Allegheny Ludlum Steel Corp., uses G-E MD-600 mill motors for lasting service on front and rear tables, feed rolls, manipulators, sideguards and screwdowns. Inset shows two of the motors driving the front table.

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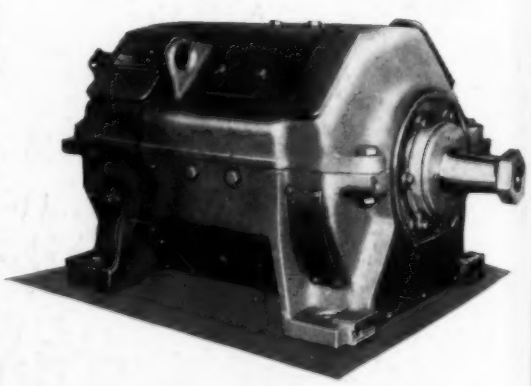
MD-600 MILL MOTORS



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